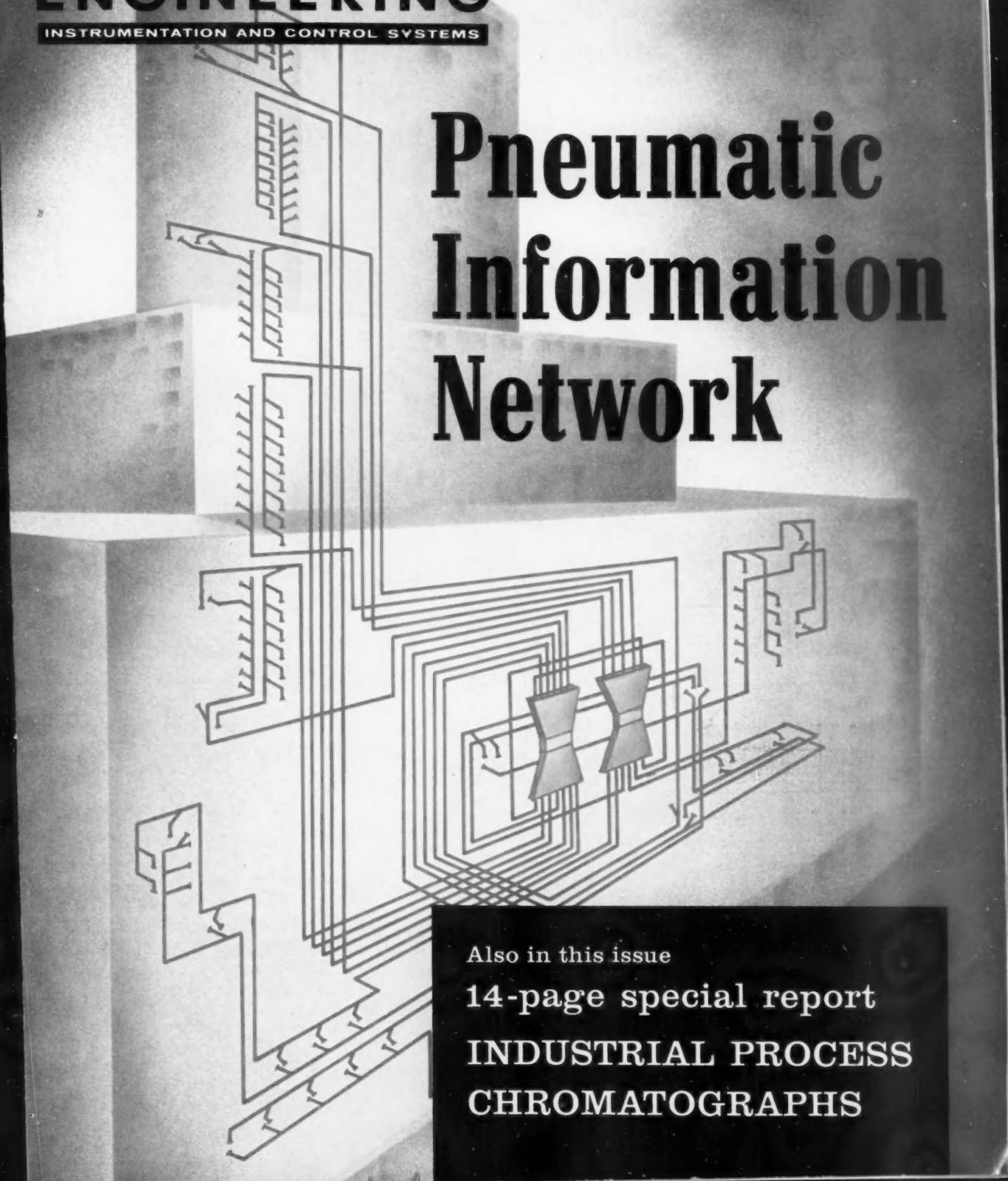
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Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

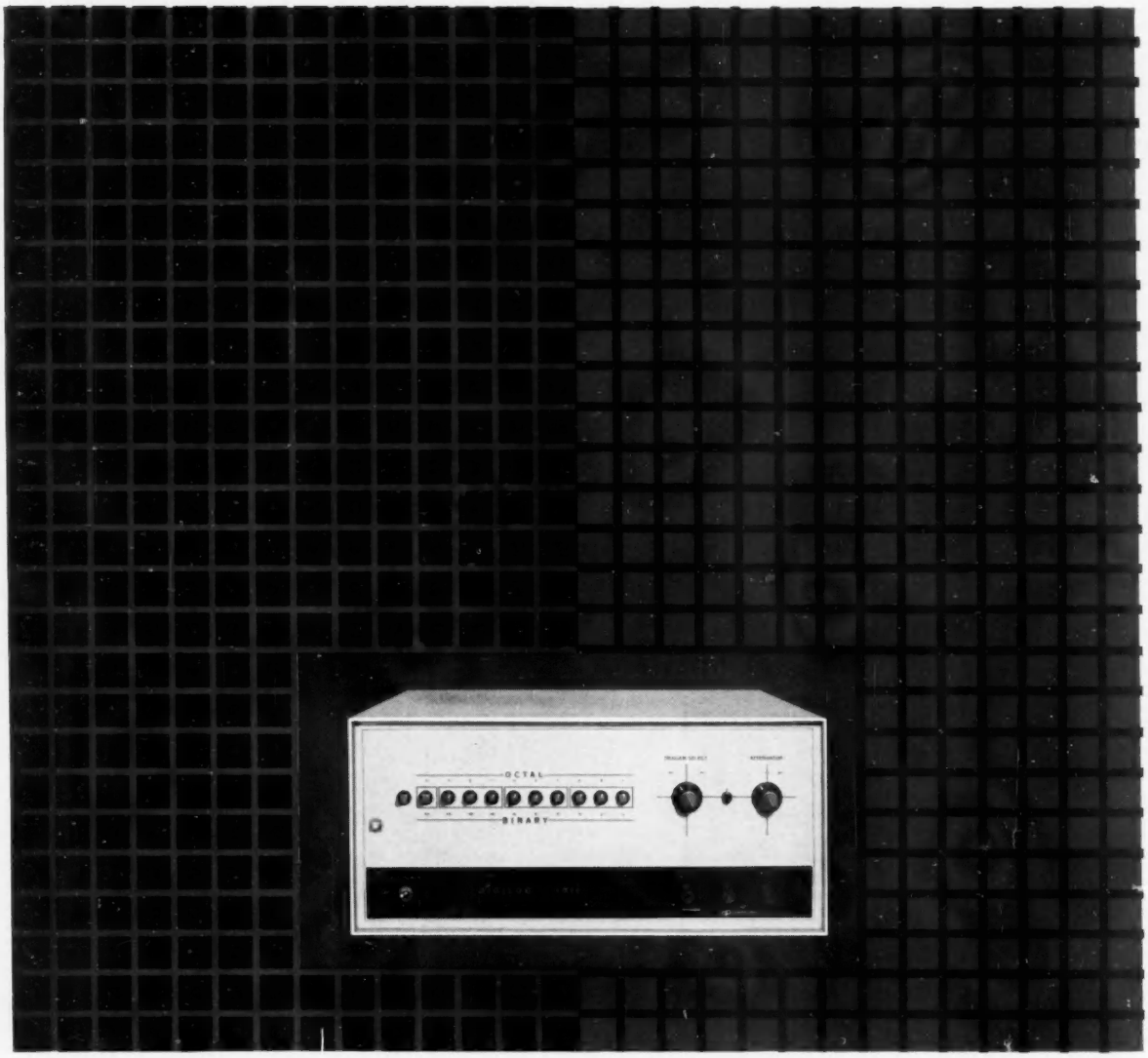


Pneumatic Information Network

Also in this issue

14-page special report

INDUSTRIAL PROCESS CHROMATOGRAPHS



INTRODUCING LIBRASCOPE'S ELECTRONIC DIGILOG*-1011 FOR VOLTAGE-TO-DIGITAL / DIGITAL-TO-VOLTAGE CONVERSIONS

Use it as a precision input unit with computers, data loggers, storage units and other instrumentation. Use it wherever conversions must be fast and accurate. For the DIGILOG-1011 performs up to 5,000 voltage-to-digital conversions per second, 100,000 digital-to-voltage per second. Digital output is 10 bits plus sign in binary and octal code, and may be serial or parallel. DIGILOG-1011's low-density component packaging results in solid-state circuitry offering exceptional reliability and life expectancy, and low initial cost. DIGILOG-1011 accepts inputs in these full-scale ranges: ±1.023v, ±10.23v, ±102.3v. Accuracy is ±0.03% ±½ bit, and stability is ±0.03%. Input resolution: 1 mv minimum. *For technical details on the* DIGILOG-1011, *write or call Librascope today.*

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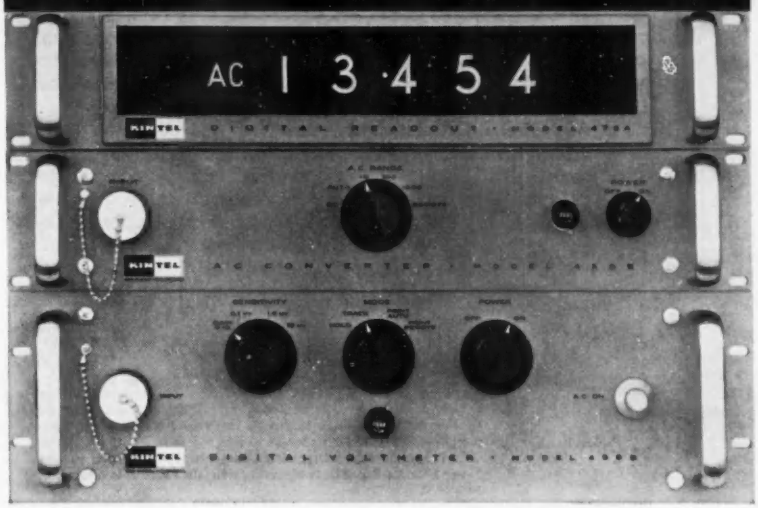
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AC/DC digital voltmeter

EXCLUSIVE FEATURES:

remote (programable) control
up to 10 times more AC and DC resolution
industry's highest AC accuracy



The Model 502B AC/DC Digital Voltmeter measures DC between ±100 microvolts and ±1000 volts, AC from 30 cps to 10 kc between 1 millivolt and 1000 volts. The readout displays 4 digits plus a 5th over-ranging digit (0 or 1) that gives 10 times greater resolution at the decade points (1, 10, 100 volts). The 502B is unique among digital voltmeters in providing AC over-ranging on the two lower manual range scales—00.000 to 19.999 volts and 000.00 to 199.99 volts.

DC measurements are accurate within 0.01% of reading ±1 digit. AC accuracy is the highest in the industry—within 0.1% of reading or ±3 digits from 30 cps to 10 kc for inputs up to 10.000, 100.00, or 1000.0 volts on the respective range scales, within the same tolerance for signals from 50 cps to 7 kc up to 15.000 and 150.00 volts on the respective scales.

The 502B is the only digital voltmeter controllable by remote contact closures. With the AC converter control set to REMOTE, contact closures can select any of the following ranges (1) 10-volt range, AC; (2) 100-volt range, AC; (3) 1000-volt range, AC; (4) auto-range, AC; or (5) auto-range, DC.

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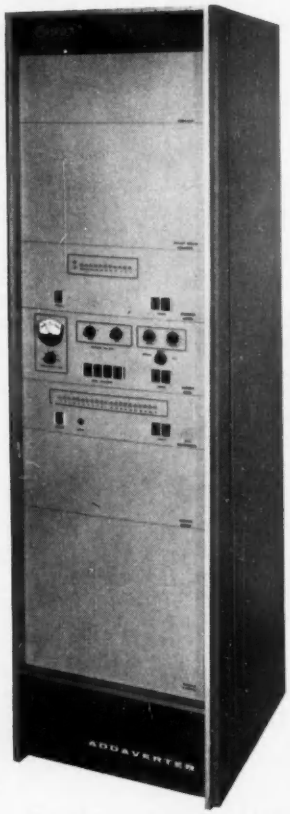
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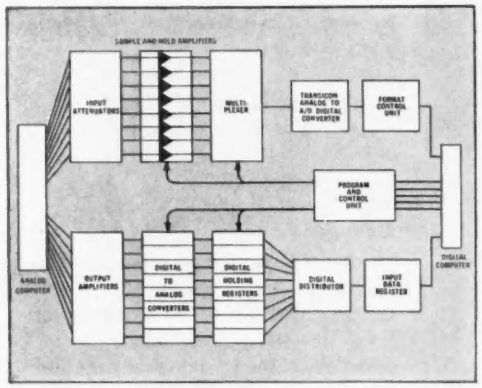


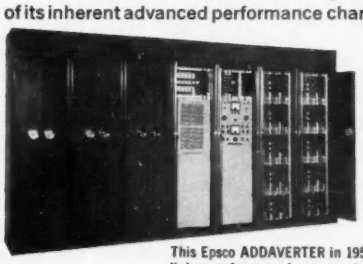
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Linkage Systems

The Epsco solid-state ADDAVERTER® provides on-line bi-directional communication between analog and digital computers. Computations may be shifted back and forth through the ADDAVERTER® in real time, combining the analog machine's rapid solution of complex functions with the high-speed programmable arithmetical capability of the digital machine.

The ADDAVERTER's® unmatched operational versatility is the result of its inherent advanced performance characteristics as well as Epsco's basic functional module approach. It requires no periodic calibration or peaking adjustment. A wide range of field-addable options permit adaptation to your exact needs.





This Epsco ADDAVERTER in 1957 performed the first operational on-line linkage of an analog computer and digital computer. Developed for Convair Astronautics, San Diego, this first model is still in active use today. A vacuum tube system with 10 D/A and 15 A/D channels, it provides linkage between a large-scale analog computer and either an IBM 704 or a Univac Scientific computer for simulation studies of a complete ballistic missile system.

KEY SPECS:

Analog/Digital	Digital/Analog
Input Signal Levels: ±128 V, ±100 V, ±10 V full scale models available.	Signal levels and format compatible with your digital computer.
Sampling Rate: Up to 15 KC.	Up to 50 KC.
Sampling and Distribution (either A/D or D/A): Simultaneous.	Sequential.

Accuracy (both A/D and D/A):
±0.05%, ±½ least significant bit
±0.01%, available on special order

Code (both A/D and D/A):
Binary or BCD.

Epsco SYSTEMS

A division of Epsco, Incorporated, 275 Massachusetts Ave., Cambridge 39, Mass., UNiversity 4-4950

Control ENGINEERING

JUNE 1961
VOL. 8 NO. 6

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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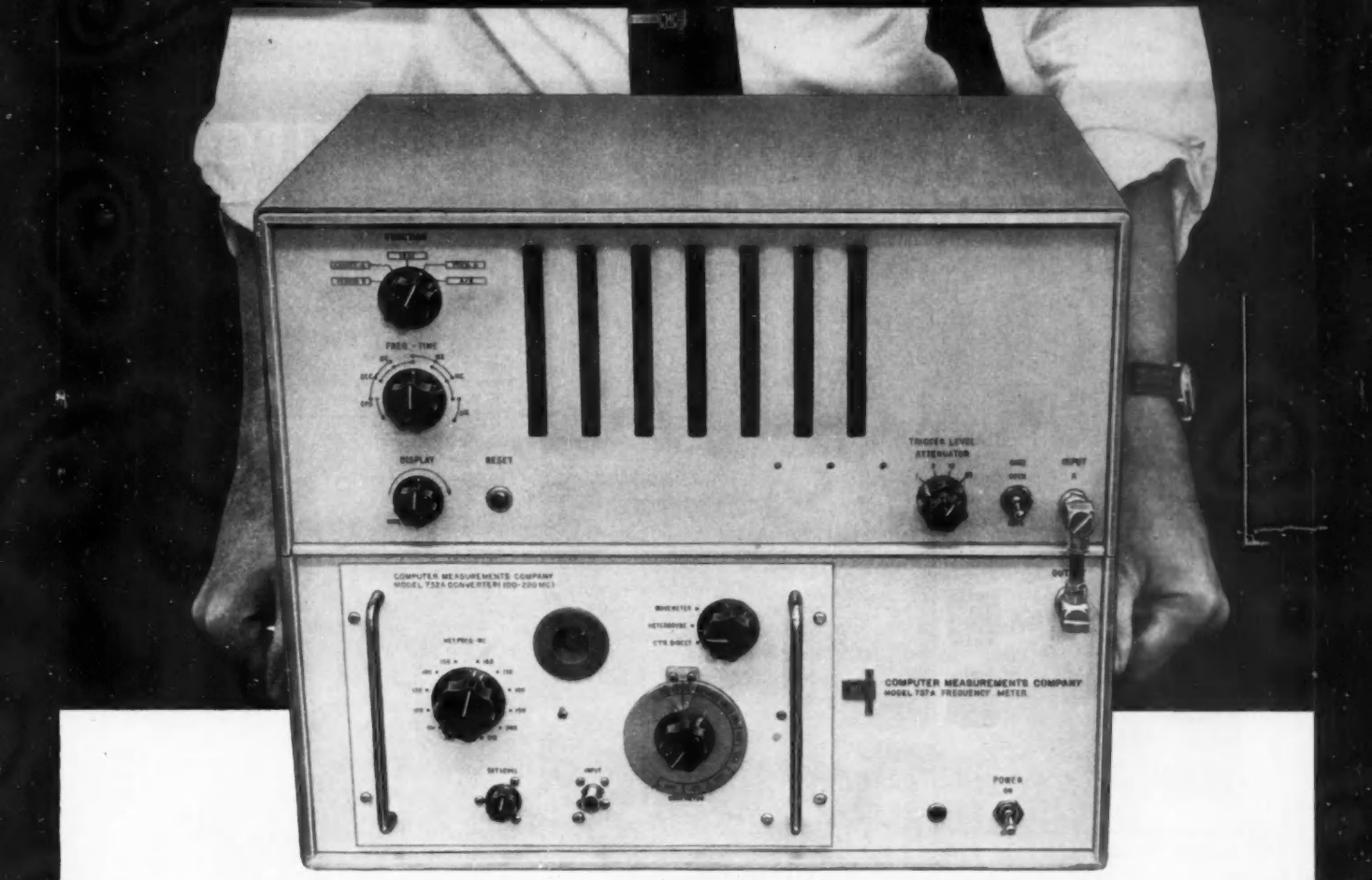
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Model 737A shown with Model 732A Converter Plug-In

→ Measure frequency dc to 220 mc

→ Measure period to 0.1 microsecond

→ Measure time interval 0.1 microsecond to 10^7 seconds

→ Compatible with hp plug-ins

CMC, first with solid state reliability, announces the transistorized Model 737A frequency-period meter.

Here, combined in one compact package weighing a scant 48 pounds, are the functions of a high speed counter, frequency meter, and period meter. Sensibly priced at $2150, the Model 737A mates an all solid state counter with a plug-in vacuum tube heterodyne converter.

Only 14″ high, 17″ wide, and 13″ deep, CMC's new Model 737A requires a mere 125 watts of power which in itself reduces operating temperatures and contributes to long trouble-free life. And except for the vacuum tubes, the new unit is unconditionally guaranteed for two years.

THREE PLUG-INS AVAILABLE

1. 10 mc to 100 mc frequency converter; 2. 100 mc to 220 mc frequency converter; 3. Solid state 0.1 microsecond to 10^7 second time interval section (Accepts hp plug-ins: Models 525A, 525B, 526A.)

Converter plug-ins $250 each. Time interval plug-in $300.

FEATURES AND ADVANTAGES ✱ *Decade count down time base, frequency divider circuits never need adjustment.* ✱ *Automatic decimal point.* ✱ *Nixie readout available as standard option.* ✱ *Stability, 2 parts in 10^7 standard, 5 parts in 10^8 special.* ✱ *Accuracy, ±1 count ± oscillator stability.* ✱ *Sensitivity, 0.25 v rms.* ✱ *Standardize against WWV.* ✱ *Remote programming without special regard to cable length, type of cable, or impedance matching.* ✱ *Printer output to drive digital recording equipment, punches, inline readout and other data handling gear, $60 extra.*

NEW 20-PAGE FULL-LINE CATALOG

Write for your free copy of the new 1961 CMC Full-Line Catalog. Twenty pages describing solid state and vacuum tube counters, frequency and time interval meters, preset counters, printers, and decade counting units.

CMC 36A

Computer Measurements Co.

A Division of Pacific Industries

12970 Bradley Avenue, Sylmar, California

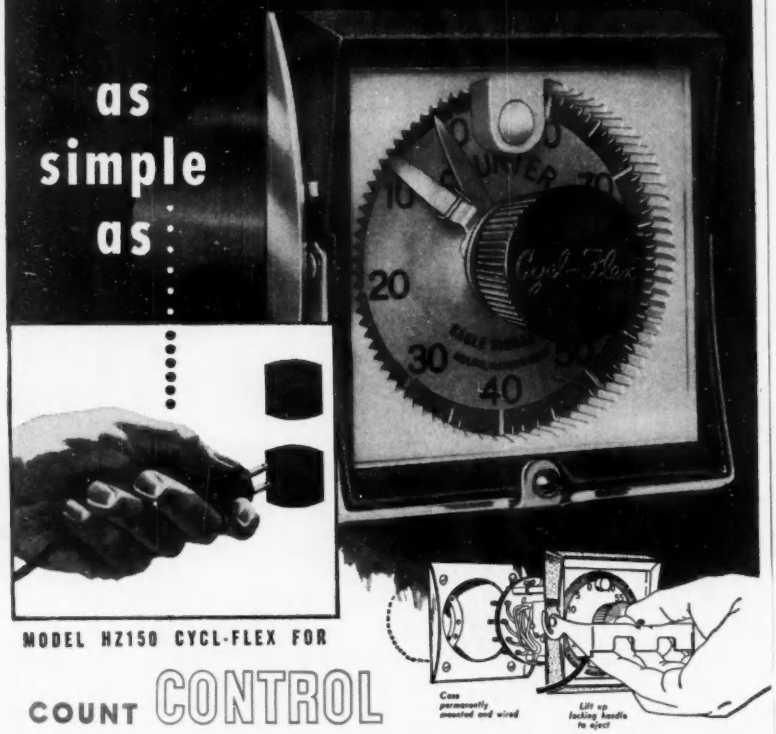
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plugging-in EAGLE'S

NEW CYCL-FLEX COUNTER

as simple as .....



MODEL HZ150 CYCL-FLEX FOR

COUNT CONTROL

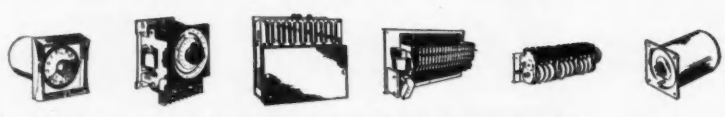
Yes, Eagle's New Cycl-Flex Plug-In Counter is as easy to adapt and change as its companion Cycl-Flex Timer. In fact, in mounting and in over-all appearance, they're exactly the same.

The New Cycl-Flex Counter does more than just count. A large variety of control circuits are yours by utilizing its one instantaneous switch and two delayed switches to control your machines or processes. Use this *count control* to automatically operate:

- The number of molding machine injection strokes
- Number of indexes on a rotary table
- Number of produced pieces before shutting off machine or conveyor

Write for Bulletin 725 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

SPECIFICATIONS • Count Range—80 counts • Electric Reset in ⅓ second • 400 counts per minute • 3-inch diameter quick setting dial with single knob • Switch rating—10 amps., 115 v., 60 cycle



Plug-in Reset Timers | Precision Interval Timers | Multiple Circuit Timers | Heavy-Duty Step Switches | Multiple Cam Timers | Hermetically Sealed Timers

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JUNE 1961 VOL. 8 NO. 6

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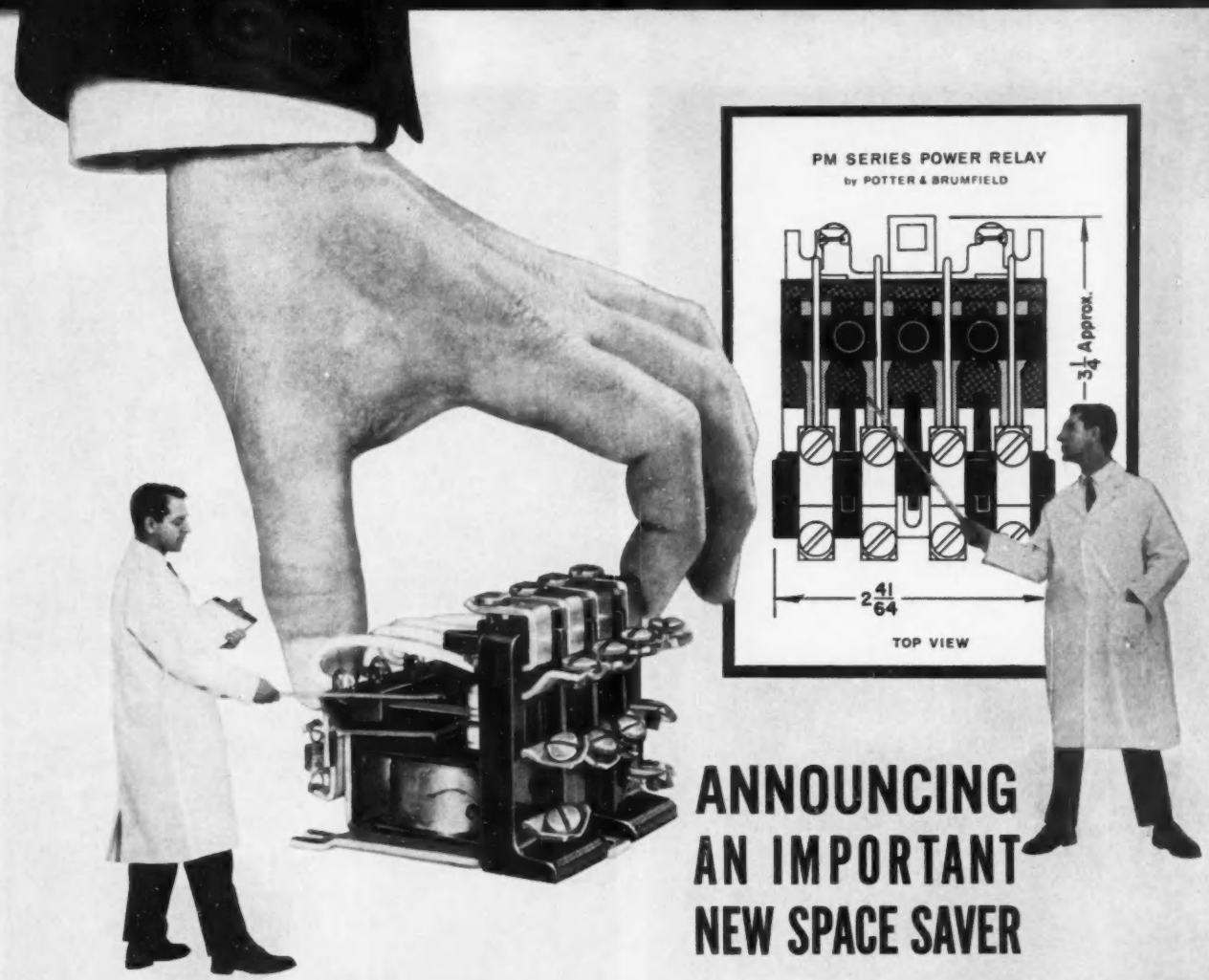
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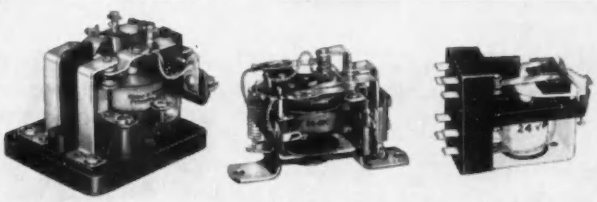
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Save panel space! This new 4-pole relay is only 1/16" wider than our PR Series, America's most popular 2-pole power relay! Yet, it is engineered for reliable heavy-duty switching . . . and you can confidently expect 10 million mechanical operations.

PM Series relays are rated at 16 amperes (or 1 H.P.) at 115 volts, 50/60 cycles resistive . . . and special relays can be supplied for loads up to 25 amperes, at 220 volts, 50/60 cycles resistive. Heavy screw terminals are arranged for fast, easy hook up. An adapter plate is available for mounting PM relays in the same location used for 2-pole relays.

For full information, write today or call your nearest P&B representative.



PR Series MR Series AB Series

A whole family of power relays for a wide range of applications carry the P&B symbol of quality. Call P&B first for all your power relay requirements.

PM ENGINEERING DATA

GENERAL:

Description: Heavy-duty AC power relay.
Insulating Material: Molded phenolic.
Insulation Resistance: 100 megohms minimum.
Mechanical Life: 10 million operations minimum.
Contact Life: 100,000 operations minimum at rated load.
Breakdown Voltage: 2,000 volts rms minimum between all elements and ground.
Ambient Temperature: −55°C to +55°C.
Weight: Approximately 14 ozs.
Pull-in: 78% of nominal voltage.
Terminals: Heavy-duty screw type with No. 8-32 BH screw.

CONTACTS:

Arrangements: 4PDT or 4PST—normally open.
Material: ¼" dia. silver-cadmium-oxide.
Rating: 16 amps @ 115 volts, 50/60 cps resistive.
8 amps @ 220 volts, 50/60 cps resistive.
1 H.P. per moveable, 115 or 220 volts AC single phase.
25 amps @ 220 volts, 50/60 cps resistive available on special order.

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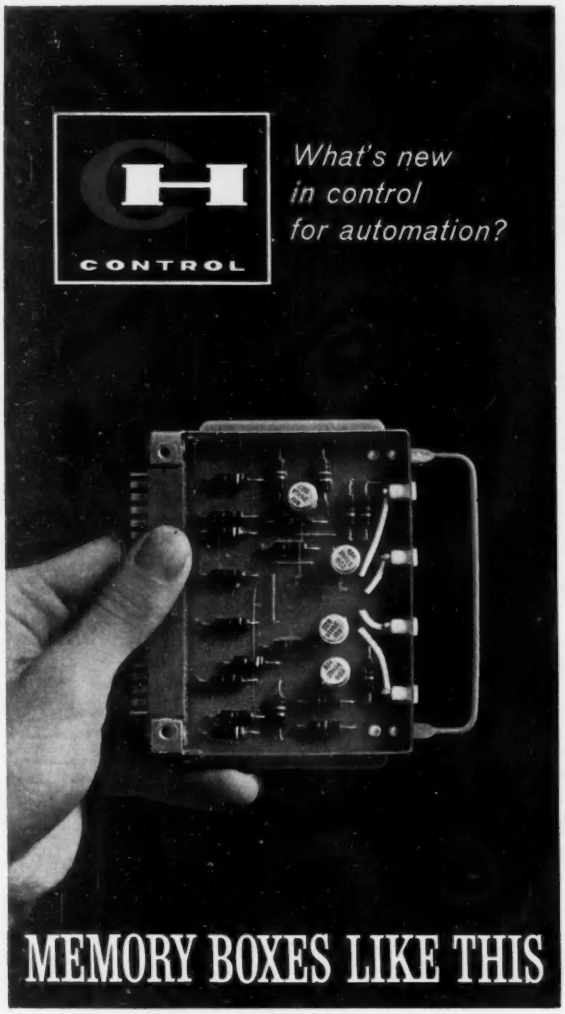
Voltage: 6 to 230 volts AC 50/60 cycles.
Power: 14 volt-amps average at nominal voltage.
Duty: Continuous.

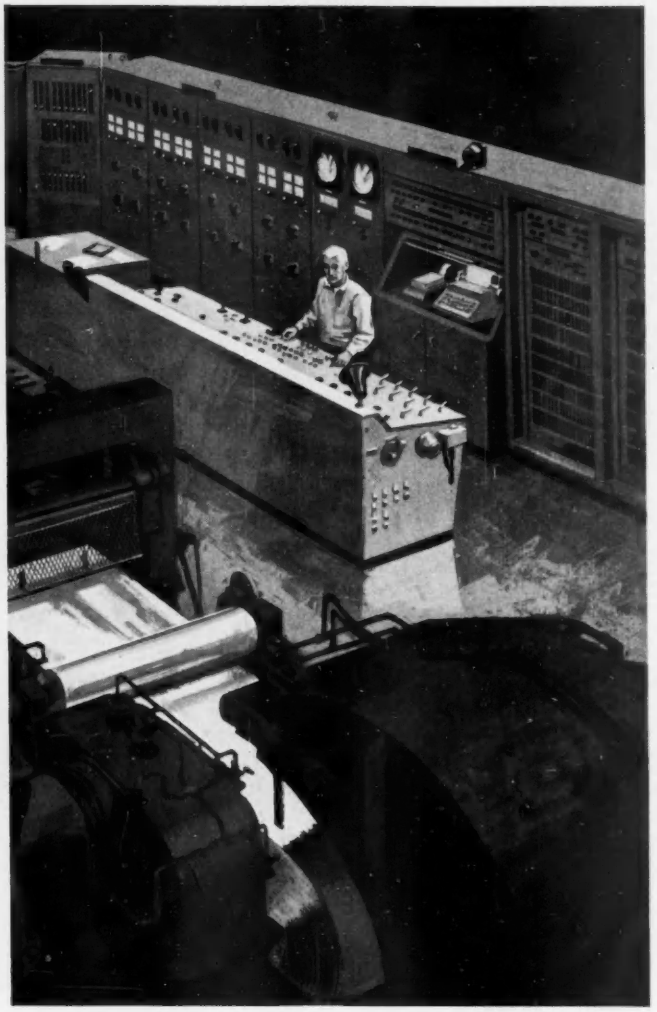
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SAVE MATERIALS . . . *to help a tinplate producer control quality,* Cutler-Hammer designed a computer that records quality in coils 3 miles long as the strip zips by at 1600 FPM. Automatically typed report shows defects and their exact location. Next automation step: process the data and close the loop by feeding the system instructions to provide automatic correction of process defects.

READ, RECORD, REMEMBER

Memory boxes like this—digital modules in various combinations—are the key to *data accumulation,* basic to automation. Data accumulation provides *facts* that enable an operator to control a process better. It provides the *complete knowledge* of what is happening in a process that is an essential preliminary to complete automation.

Three examples of data accumulation that have paid off are shown above. Applications are as broad as your problems and engineering imagination. Typical applications are designed to improve production and inventory control, to provide better sales forecasting, more intelligent production scheduling and cost control.

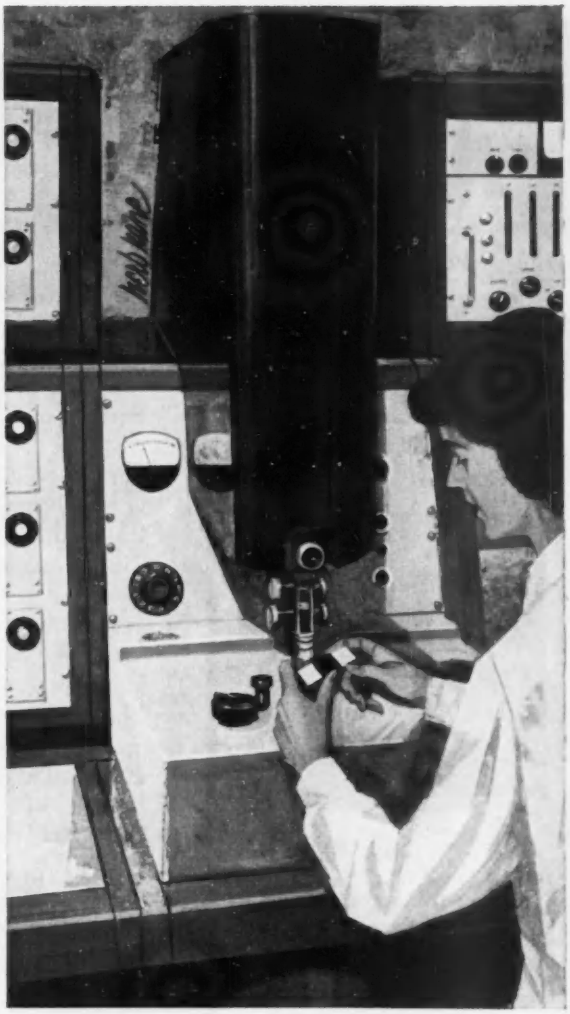
Automation systems designed by Cutler-Hammer run the gamut from material-handling systems that automatically regulate flow of car bodies from warehouse to assembly, to automatic blast furnace charging.

COMMON DENOMINATOR OF SUCCESSFUL AUTOMATION

You, and your automation planning team, can establish the needs for automation in your company far better than anyone else. But when objectives are determined, an automation control specialist can help you increase efficiency and cut costs . . . especially when he is *called in early.* He will help you select data processing equipment with the exact degree of sophistication for your needs; make sure that control and mechanical drive are compatible.



SAVE TIME . . . *to prevent production delays,* a buffer storage area between car body plant and assembly was designed by Cutler-Hammer engineers. One operator assigns body styles to assembly in sequence to maximize production, utilizing simplified data processing which "remembers" each car body location. This Cutler-Hammer idea saved the manufacturer many thousands of dollars.



SAVE LIVES . . . *to help detect cancerous cells* faster, a Cytoanalyzer developed by Cutler-Hammer's A.I.L. Division counts and classifies cancer cells according to nuclear size and density. This electronic slide scanning device greatly reduces time formerly required for visual examination. Early and regular cytological tests, made practical by this system, could reduce uterine cancer deaths substantially.

Employment opportunities are available for qualified engineers.

WHAT'S YOUR AUTOMATION OBJECTIVE?

Chances are Cutler-Hammer engineers can utilize their automation experience and adapt existing techniques to help solve your problem. Or, they'll use their ingenuity to develop a completely new concept. Either way, you have everything to gain from their experience. Why don't you call in your Cutler-Hammer man this week?

WHAT'S NEW? ASK...

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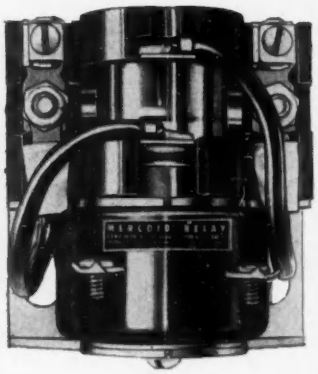
CONTROL

35 AMP

* 120V. Non-Inductive A.C. heater loads

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by

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If you need reliability and durability, this quality built relay by Mercoid is your answer.
For heavy duty loads, such as resistance heating, (domestic, commercial, industrial)—heat treating furnaces, drying equipment, welding, lighting, illuminated signs, score boards.
Hermetically sealed mercury to mercury contact provides visible on-off operation. Silent and chatterless. Quickly mounted, easily wired. Speeds up to 100 operations per minute.

* Available normally open;

CONTACT RATING:

LOAD			*NON INDUCTIVE HEATER LOADS	
	AC	DC	AC ONLY	
120V.	30A.	15A.	120V.	35A.
240V.	20A.	10A.	240V.	25A.
440V.	8A.	—	440V.	10A.

WRITE FOR BULLETIN 0-20

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

SHOPTALK

Meet Bob Heslen



Newly added to CONTROL ENGINEERING's staff is Associate Editor Robert F. Heslen. Bob took a BA degree from the University of Chicago, followed by postgraduate work at the Sorbonne. This led to an assignment with the U. S. government, conducting weapons production facilities surveys in France for the NATO buildup. Returning to the United States, Bob's work in manufacturing facilities brought him to the Industrial Controls section of Bendix, where he wrote technical manuals and conducted training on numerically controlled machine tools. From director of publication and training at Bendix, he moved on to become controls editor for *The Tool and Manufacturing Engineer*. Bob's experience in both manufacturing and controls culminates, logically, in his assignment as manufacturing control editor for CtE.

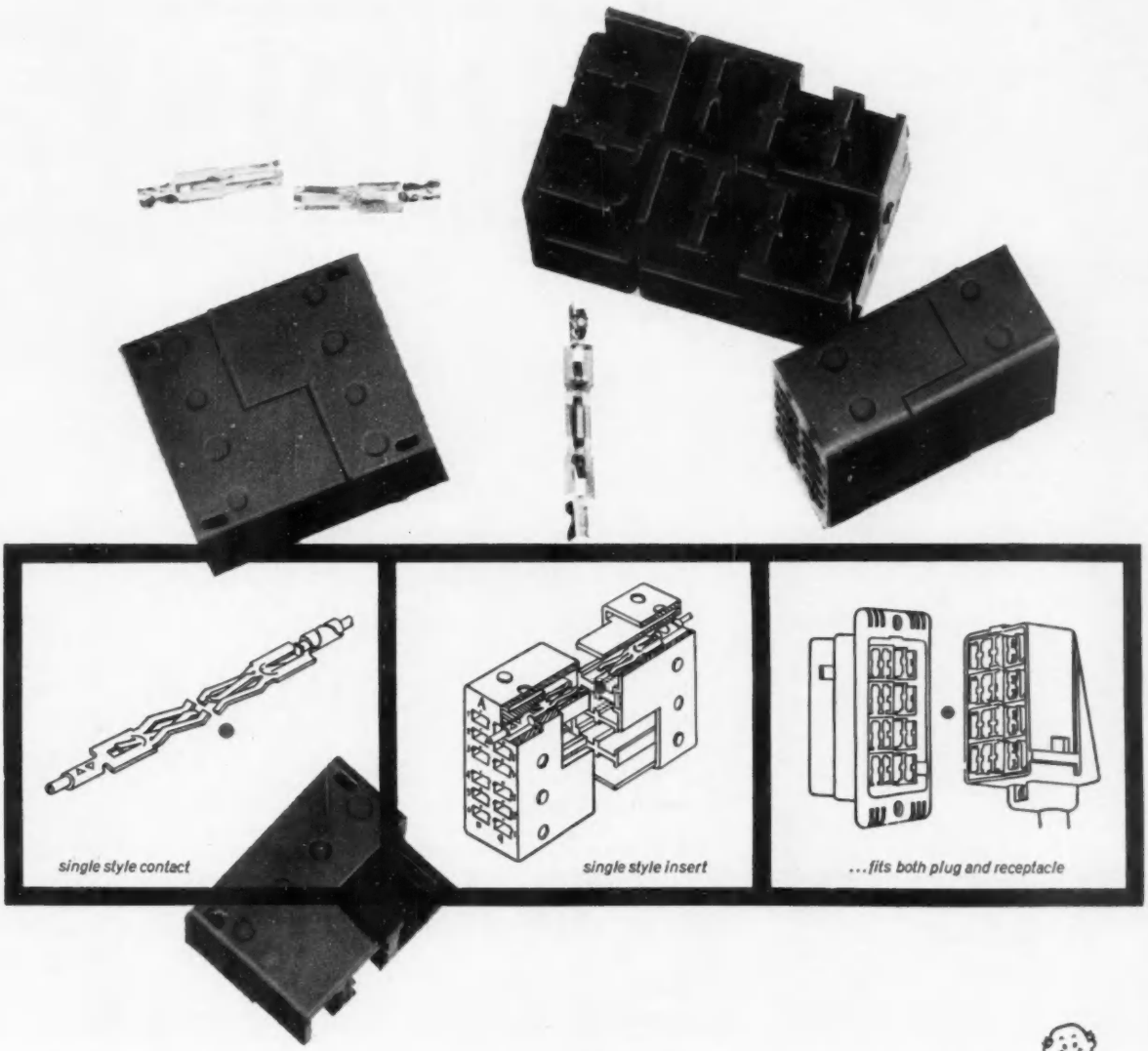
Editorial Look-Ahead

Early in April the entire CONTROL ENGINEERING staff took off for its annual two-day work-and-fun conclave at the Sedgewood Club in upstate New York. Reason: Editorial refurbishing. (We refurbish more than once a year, but not always in such beautiful bucolic surroundings.) Away from the din of typewriters and telephones, editors told each other the significant control interest, techniques, and equipment they plan to cover in upcoming issues.

In attendance were CONTROL ENGINEERING's consulting editors Mergler, Faulkner, and Vannah, and invited guest Kazuto Togino, who serves as CtE's correspondent in Japan. Kazuto, who is chief researcher in Government Mechanical Lab., Tokyo, is now studying at Case Institute in Cleveland. He flew east with Harry Mergler and drove up to Carmel, New York, in time to join us for dinner and to portray for us the growth of control in Japan and the impact this technology is having on that country's economy. For a comprehensive resume of Kazuto's remarks, turn to page 32.



Here you see Kazuto in conversation with Chief Editor Byron Ledgerwood, right, and CtE Chicago District Manager Milt Steinbraker, left.



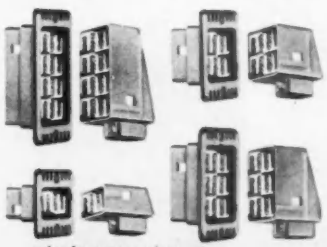
CANNON morpho* PLUGS



A NEW DEVELOPMENT FOR INDUSTRIAL AND MANY MILITARY APPLICATIONS

The unique hermaphrodite-modular design of Cannon's new MORPHO lightweight plugs provides unusual flexibility and versatility! Especially intended to meet commercial applications such as computers, business machines, and communication equipment inexpensively and with complete reliability—these unusual plugs are equally well suited for many military requirements. The MORPHO line features hermaphrodite crimp type contacts and hermaphrodite modular insulators which fit both plug and receptacle. Currently available in 12, 24, and 36 contacts...allows numerous alternate insert positions.

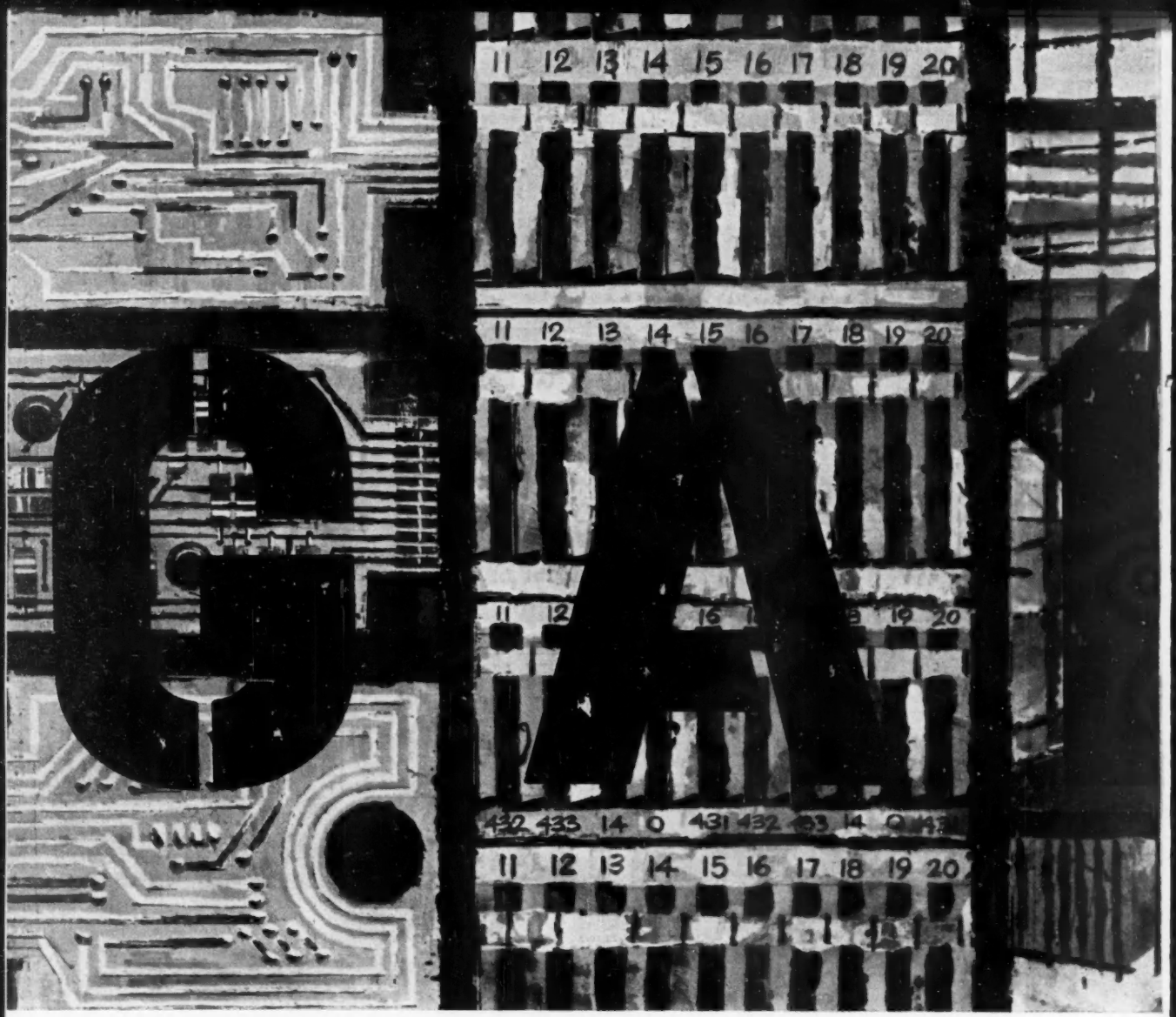
Write for Catalog MH-1 today for the complete story of MORPHO ...another reason why you should consult the world's most experienced plug manufacturer for all your plug requirements.



* tradename pat pend

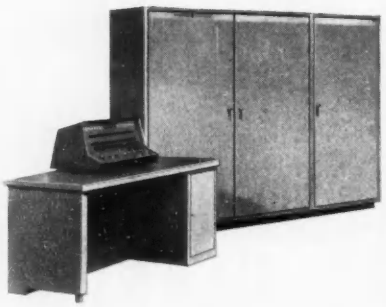
CANNON PLUGS

CANNON ELECTRIC COMPANY • 3208 Humboldt St., Los Angeles 31, Calif.



G Gathers automatically the information the operator needs to supervise the plant.

A Alarms off-limit quantities... automatically warns when an unsafe value occurs and logs all points exceeding pre-set limits.



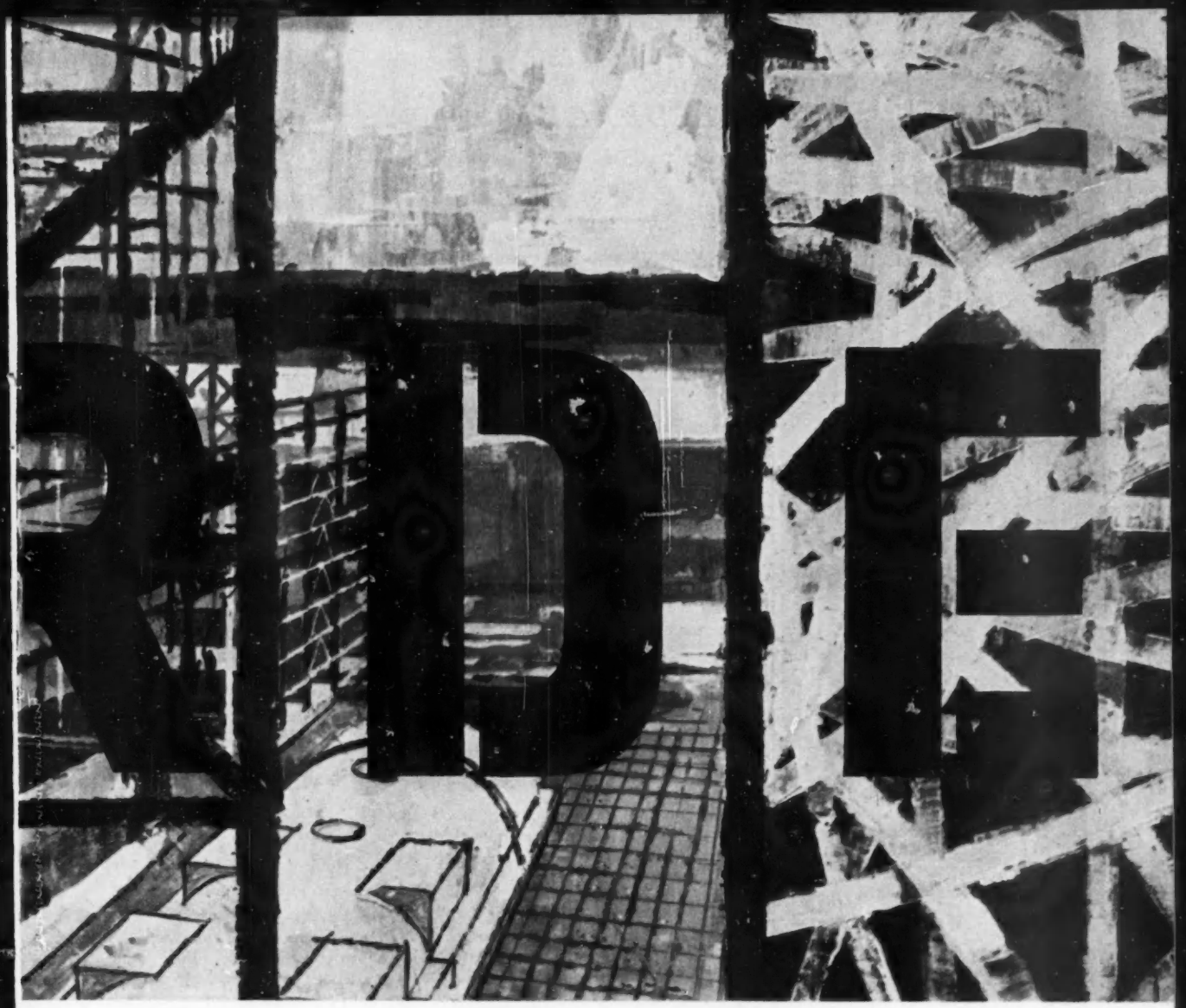
NEW GENERAL ELECTRIC COMPUTER SYSTEM

designed solely for electric utility steam power plant data processing

HERE'S HOW GENERAL ELECTRIC'S ADVANCED DESIGN SYSTEM LOWERS OPERATING AND MAINTENANCE COSTS...

GARDE is General Electric's process computer system designed especially to meet the problems and needs of electric steam plant data processing. The GARDE system gathers, alarms, reports, displays, and evaluates data from several

PCA-1



R Reports... automatically prepares a complete log of all operating conditions hourly or on demand.

D Displays... continuous visual display of any input or computed value that the operator chooses.

E Evaluates... over-all plant and key component performance hourly—or on demand.

hundred inputs located throughout the plant. It warns of abnormal deviations in those process conditions which cause equipment stress and inefficient operation. Early detection of these saves dollars in equipment maintenance and increases operating efficiency.

In addition, the GARDE system checks itself—detecting faulty sensors and other components. Its continuous reports are invaluable in periods of rapid operational changes. One of its provisions guides the operator through complex plant operating routines, helping him avoid errors and resultant equipment outage.

GARDE system evaluates these key plant operations: Boiler efficiency • Turbine Generator Heat Rate • Station Heat Rate • Correction of Heat Rates to Bogey Conditions • High Pressure and Intermediate Pressure Turbine Efficiency • Feedwater Heater and other Equipment Performance • Condenser Performance.

General Electric was able to design the GARDE system because it leads all manufacturers in process computer systems installed or ordered by the utility industry. The near-million man-hours of application and research in its design were spent in implementing systems for users. Out of this experience, came the GARDE process computer system.

Investigate this newest development in data processing for steam plants—contact your nearest General Electric Apparatus Sales Office or Process Computer Section, Industry Control Department, P.O. Box 2918, Phoenix, Arizona.

In Canada, contact Canadian General Electric Apparatus Sales Department, Peterborough, Ontario.

Outside the U.S. and Canada, contact International General Electric, 150 East 42nd Street, New York 17, New York.

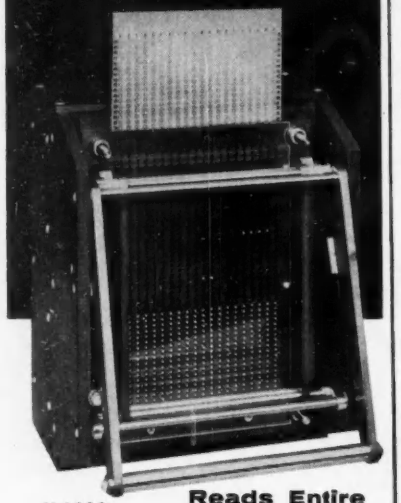
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FOR

Simple Switching Using Standard Punched Cards

This Taurus Punched Card Sensor, with 1000 switches, is programmed by a special Taurus card made of mylar.*

Each hole position has a corresponding closed switch, and each unpunched hole position has a corresponding open switch when the Sensor is actuated. Used for Automatic Test Equipment and other automation devices.

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*REG. T.M. OF E.I. DUPONT

FEEDBACK

Here's the answer, but where's the questioner?

To the Editor—

I am a subscriber to Control Engineering. I consider it a very valuable publication and maintain a looseleaf notebook of the articles of special interest.

I am writing to ask where I might find a complete derivation in English of the Leonhard criterion. In a course I am taking we're given only the criterion and not the mathematical derivation. I don't think the criterion is any better than the generalized Nyquist criterion for stability. However, I feel I should know it thoroughly. Perhaps someone could write an article on the Leonhard criterion.

John S. Reese
Commander, U.S.N. (Ret.)

Feedback would like to thank Prof. John G. Truxal, Head of the Department of Electrical Engineering, Polytechnic Institute of Brooklyn, for the following information:

"The Leonhard stability interim, referred to in the German literature as the graphical (in contrast to the algebraic criterion by Routh) or the phase criterion (Phasenkriterium) is to be found in:

1. A. Leonhard: "Die Selbstatige Regelung", Springer, Berlin, 1949.
2. H. Kaufmann: "Dynamische Vergange in Linearen Systemen der Nachrichten und Regelstechnik", Section 5.2, pp. 98-101, R. Oldenbourg, Munich, 1951.

The criterion was developed by Leonhard in 1943.

"I am not aware of any reference in English that is reasonably complete, but the above are largely mathematical and hence relatively easy to read."

Unfortunately we were unable to pass this information along to Commander Reese since there was no address on his letter. To locate an individual on CtE's subscriber lists we need at least the state he lives in. If you spot this, Commander Reese, keep your eyes open for a down to earth article comparing the Nyquist, Leonhard, and Routh criteria that will be published in Control Engineering before the end of the year. Our job is to interpret analytical techniques in the light of their usefulness to practicing engineers. Ed.

A difference of opinion

To the Editor—

I would like to correct an error which appeared on page 42 of your February 1961 issue in a news item, "Switch to Blend–Electronically".

The Union Oil Co. blending system referred to in the article resulted from a two year development by Waugh Engineering Co. in conjunction with Union Oil. Packard Bell Computer entered the picture about midway in this period as a subcontractor for the design and packaging of the control circuitry.

The Union Oil blender is the first automatically controlled blending system for the petroleum industry to use turbine flowmeters combined with completely digital control techniques. The Wilshire Oil Company blender also referred to in the article uses an analog (potentiometer) setting of blend ratios and therefore cannot be classified as a digital system.

Charles C. Waugh
President
Waugh Engineering Co.
Van Nuys, Calif.

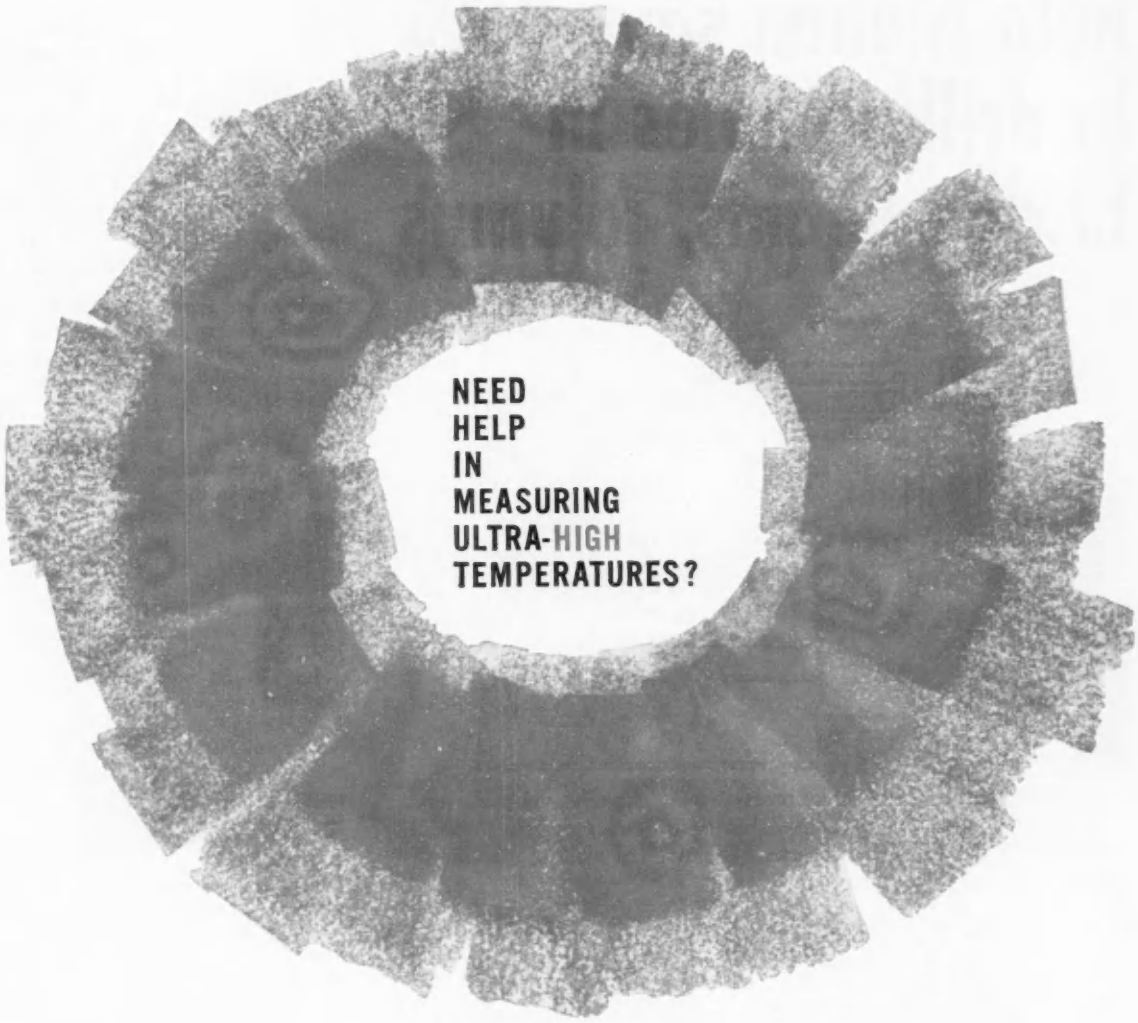
Japanese control computer competes

To the Editor—

Our economics class discussed the report in the February 1961 issue (p. 41) that the Japanese are producing a process control computer that "looks like and is said to have similar capabilities as the American TRW Computers RW-300."

In your November 1960 issue you reported in much detail that Monsanto's ammonia unit is now under complete full-time control of an RW-300 digital computer. It seems incredible to the class that the Japanese would have the brain power and the facilities to produce a copy of the RW-300 and to do it in so short a time after it was put on the market. Can you tell the class how the Japanese produced the computer? Did they buy one and reproduce it? The American company must have spent a lot of money on research and development. Did the Japanese cash in on this research and development?

Obviously, the Japanese can produce the computers for much less than the American company. Doesn't that disturb you? Doesn't that mean its low cost will make it available to Japanese



"Ultra-high" can be any temperature beyond the range of your present measuring instruments. It might be 2000°F., 5000°F., or higher.

If you have temperature measurement problems that exceed the capabilities of generally available hardware or application experience, Honeywell's basic research, design, or production areas may have the answers you need.

Honeywell research and design specialists have been and still are extending the state of the art of high-temperature measurement. Write Dr. W. E. Kuether, MINNEAPOLIS-HONEYWELL, 151 E. Hunting Park Avenue, Philadelphia 24, Pa.

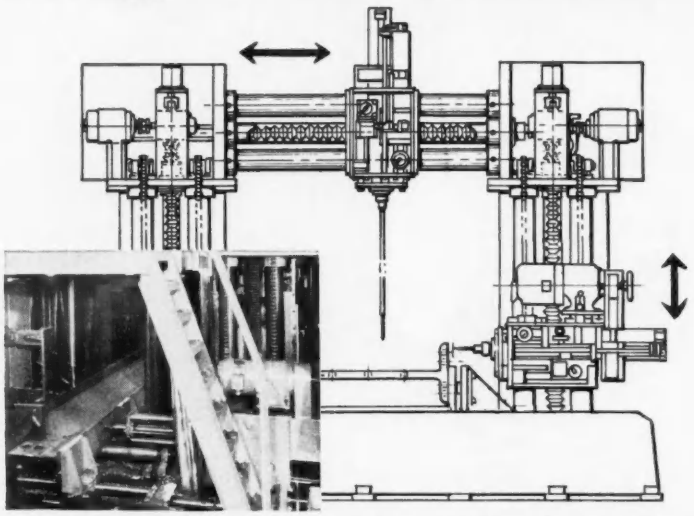
Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Beaver Ball Screws help Mahon save 85% in drilling holes in bridge beams, columns

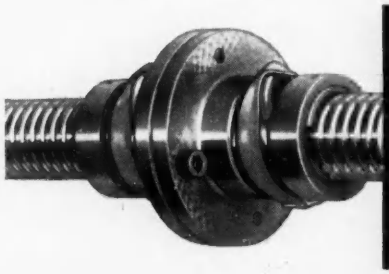


Close tolerance positioning of massive 1½" capacity vertical and horizontal drill heads is accomplished with Beaver ground-thread ball screws in this new, numerically controlled drilling machine, first in the structural steel industry.

Walter P. Hill, Inc., designed and built the machine for The R. C. Mahon Co., Structural Steel Division

In addition to the important drilling cost savings, it offers repeatability in hole pattern accuracy within ±.005" as compared with ±⅛" by conventional methods and eliminates costly hole reaming in final assembly.

If you are considering data control, Beaver ball screws will give you the power efficiency, positioning control and compactness you need. Our engineers will be glad to work with you just as they did, in this case, with the Walter P. Hill designers.



Beaver Precision Products INC.
CLAWSON, MICH.

FEEDBACK

factories and that they will thus be in a position drastically to undersell our factories who don't have process control computers?

Brock Morton
Rochester, N. Y.

No installations, no competition

TO THE EDITOR—

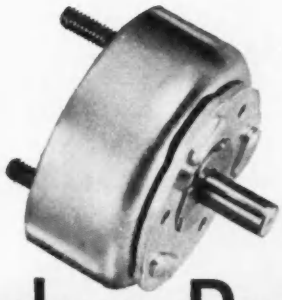
We have been actively engaged in marketing the RW-300 in Japan. It has been our experience that the Japanese technology, at least in our customer industries, is quite advanced, and we should not be deluded into thinking that the Japanese are technologically a backward people. Quite to the contrary, their state of technology is well comparable to ours. If this is true in the process industries, I expect it is equally true in the electronics field, and there is nothing surprising about the fact, or presumed fact, that a Japanese company might have a process control computer on the market with capabilities similar to our RW-300.

Let me add, however, that the fact that the computer may look like the RW-300 and may, at least on paper, have similar capabilities to the RW-300, we know of no installation of process computers in Japan for control purposes. Additionally, having a similar appearance and similar asserted performance capabilities is still a long way from proving a satisfactorily performing installation. We have many operating installations in the United States, each of which has a proven record of extremely high reliability (in excess of 99.5%). We would be more concerned if we were to have a reliable report that there was an operating on-line control installation in Japan that had displayed similar capabilities.

Mr. Morton's next to last paragraph expresses concern that a significantly lower cost computer made available in Japan might place Japanese industry at a substantially competitive advantage with American companies who do not have process control computers. I can only say to this that any American company who is interested and can establish economic justification for a process control computer can come to us and we would be happy to help him improve his relative competitive position.

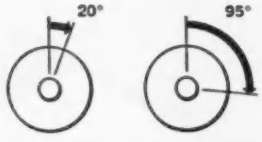
Joseph F. Manildi

TRW Computers Co.
Beverly Hills, Calif.



Ledex Rotary Solenoid

BASIC INFORMATION



Standard Ledex Rotary Solenoids will provide rotary strokes from 20° to 95°.



Action is snap-type, with spring return to starting position after completing stroke.



Action is instantaneous, approx. 1/30 sec. for 35° stroke and return.



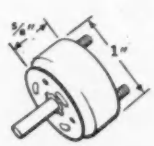
Available in left hand stroke as well as right.



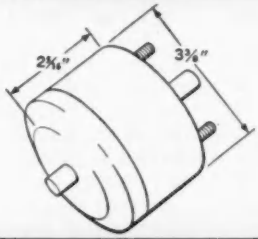
Standard Rotary Solenoids provide torque almost equal throughout stroke. Higher starting torque models can be designed.



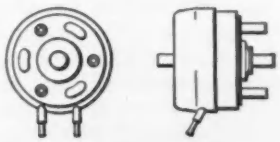
Will also provide powerful, highly efficient, short stroke piston action.



Smallest is size 1E, bare weight 1½ oz., torque up to .8 pound inches.



Largest is size 8S, bare weight 4 lbs. 3 oz., torque up to 50 pound inches.



Standard power take-offs include armature plate with three tapped holes and shaft extension from either or both ends. Special designs available.

The Ledex Method of actuation and control gives instantaneous high-torque-to-size rotary motion and high-thrust-to-size piston motion, for reliable remote mechanical actuation or remote control of rotary-type switches.

The efficient Ledex Rotary Solenoid is the heart of this method. Available in 8 compact sizes, with operating voltage from 3 to 300 V.D.C. Over 240 stock models ready for immediate shipment. Used in thousands of applications including valves, tape recorders, waveguide switches, sorting equipment, gyrocaging, computers, wireless teletypes, vending machines, typesetters, missile guidance and ground support equipment.

Other Ledex Method products are Syncramental Stepping Motors, Rotary Stepping and Selecting Switches. Write for Bulletin A-1259, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.

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High-torque-to-size rotary motion
High-thrust-to-size piston motion



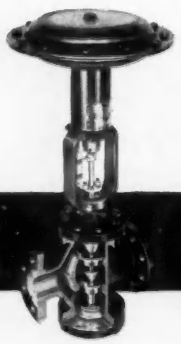
NEW DUCTILE IRON DIAPHRAGM CONTROL VALVES ARE TOUGH AS STEEL, BUT LOWER IN COST

K&M control valves made of ductile iron can save you a lot of price/performance juggling. Stronger than steel valves, harder than steel valves, they cost about 15% less. You can use them in processes where cast steel used to be an absolute must—applications calling for temperatures from −20°F to 650°F and pressures up to 1,000 psig.

Ductile iron, a metallurgist's pipe dream just a few years ago, makes castings that are as pressure tight as steel and as corrosion-resistant as gray iron. The castings have a better surface finish than steel and are easier to machine; inner contours are smoother, less subject to erosion. Ductile iron is strong enough (tensile strength—70,000 psi, yield strength—50,000 psi) and hard enough (160 Brinnell) that we even recommend its use in K&M split-body valves—formerly made only with steel bodies.

Ductile iron is available as a standard body material with all K&M valve series, and in all valve sizes. In addition, it is recommended as a topworks material for applications requiring high shock and vibration resistance. Both topworks and bodies are available in production quantities now . . . ready for dependable on-stream service for years to come.

Complete information is available either directly from K&M or from your local K&M sales representative.



K&M

diaphragm control valves

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S.A. 1920

Josef H. Hengstenberg

practical but daring

Josef H. Hengstenberg likes to say that a control engineer needs a good understanding of the fundamentals of physics and chemistry. He has parlayed his own strong background in these subjects into a reputation as the outstanding German practitioner of control systems engineering today. At Badische Anilin- & Soda-Fabrik AG he not only heads the instrumentation department—with its 1,000 employees—but is also a director of the big German chemicals producer.

His rise to such an influential position in BASF can be traced to his ability to keep economics constantly in mind while exhibiting technical daring in instrument and controls application. A case in point is the company's newest instrumentation program in which Hengstenberg and his research team are installing the first process control computer in Germany for closed-loop control. During a careful nine-month study of the process prior to installation, Hengstenberg's group found function linkages not previously suspected. As a result of this discovery, adjustments to conventional controls have already saved enough to pay for the computer, a TRW Computers RW-300. Now Hengstenberg is looking for computer control to produce even more savings.

As a young college student, Hengstenberg couldn't quite settle on a field for a career. In 1922 he started to study mathematics. A year later he transferred to Munich to major in theoretical physics. After a year he moved again, this time to Freiburg University to major in experimental physics.

At Freiburg, he worked with Professor Mie on X-ray diffraction of organic substances, work that won him his doctorate in 1927 and an offer to join BASF's research department.

His first work at BASF extended his doctoral studies; he concentrated on determining the effects of X-rays on high polymers. In the early thirties, he was made assistant manager of one of the company's impregnating emulsion producing plants.

In 1939, Hengstenberg's unofficial interest in instrumentation was made official. He was appointed instrumentation chief for one half of BASF's four square mile plant which manufactured plastics, solvents, dyestuffs, and inorganic compounds. One of his first assignments was a crash program to develop instrumentation for a GRS synthetic rubber plant; at the same time he was coordinating instrument development in three other plants. All these were unique at the time because they used 40 to 50 on-stream analyzers developed by his team.



Thinking back, the 57-year-old control engineer says, "At that point, we were ahead of the world in analytical equipment."

World War II slowed Hengstenberg's development work, and by the time he was able to reinstitute a research effort in 1948, the German process instrument industry had dropped behind the rest of the world. To speed its recovery, he recognized that the struggling instrument makers needed help from user companies like BASF, help such as guide lines on which to develop new products. He, along with Dr. Sturm and Dr. Winkler, proposed a users association that would write specifications for new instruments. Today Hengstenberg is one of the three joint presidents of the association NAMUR which has implemented that suggestion.

As German instrument makers struggled to catch up with postwar technology, Hengstenberg recognized another danger. The makers were threatening to flood Germany with different models of the same kinds of instruments. To combat this tendency, the BASF executive formulated a standardization policy within the chemical company. In the last three years, since he was made head of all BASF instrumentation, Hengstenberg has standardized 80 percent of all new instruments.

For the future, Hengstenberg has set his sights on more all-electric measurement and control. But this control engineer now plans to concentrate on improving instrumentation quality rather than increasing the number of types of devices.

if PANEL SPACE or PORTABILITY is your problem...

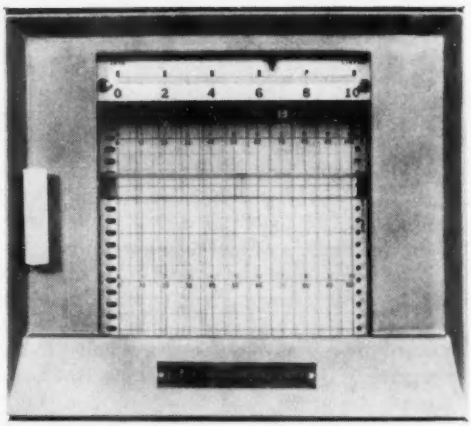


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Westronics manufactures a complete line of miniature and full size recorders with more optional features than any other manufacturer.



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Newsbreaks In Control

British Shy from NASA Contracts

London—British instrument and control companies are turning down contracts from the U. S. National Aeronautics and Space Administration. They fear losing patent or design ownership if they accept a NASA order. In England, businessmen have interpreted NASA patent rules to mean that rights to any invention made in a contract placed by NASA or to which NASA contributes financial aid belong to the U. S. government.

Japan Eyes Small Computers

Tokyo—The abacus, traditional calculator of small and medium-sized Japanese business, is headed for obsolescence. At the 1961 Tokyo International Trade Fair, a number of very small electronic data processors (priced as low as 965,000 yen, or $2,700) drew unexpectedly heavy traffic. Reason for the interest: growth of credit and international business requires more than just a calculator like the abacus.

UOP Broadens Computer Control Approach

Chicago—Change in Universal Oil Products' approach to computer control was noted at the company's stockholders' meeting. Word leaked out that UOP will install a large-scale computing control system later this year rumored at the Clark Oil & Refining Co. refinery at Blue Island, Ill.). Previously UOP had concentrated on "economical, easily designed computer-operated systems" with a special purpose digital machine built by Daystrom. Now UOP plans to follow up both general purpose and special purpose approaches, ultimately to bring a refinery under control.

IBM to Apply Computer-Control to Paper Industry

Lewiston, Idaho—When IBM dedicated its new research laboratories last month, the company showed off a miniature paper-making machine, said it would study comuting control in papermaking. In mid May, IBM announced it would deliver an IBM 1710 computer to Potlach Forests, Inc., in September to control a 500 foot long paperboard machine. Main advantage of computer control, says Potlach vice president, V. V. Vallandigham, will be better quality (papermaking is still pretty much an art), less off-specification, and shorter time to change product grade.

Air Force Interested in Film Memory

Los Angeles—U. S. Air Force has awarded Marquardt Corp. a research contract to prove feasibility of the company's high density photographic storage technique. Proposed to store topographic detail, the memory has a capacity of 10^7 bits of information per square inch. Marquardt calls its system multichannel memory because information is stored on multicolored film transparency, each color serving as an additional storage surface or information channel.



From electromagnetic search . . .

to electronic computer



Information Retrieval:
finding a needle in a haystack

How can an engineer find the one or two applicable references in the whole body of technical literature? Automatic information retrieval opens up a new operatoin that includes optical character sensing, automatic abstracting, automatic translation, and computer search. One link, computer search, has started at Western Reserve University.

CLEVELAND—Is a general purpose electronic digital computer a practical tool for information retrieval? Finding the one, two, or half dozen key references in a whole body of technical literature? This question, hotly debated at library and technical meetings, moved closer to an answer last month when General Electric delivered a GE 225 machine (GE's first installation of its medium-sized digital data processor) to the Center for Documentation and Communication Research at Western Reserve University. At WRU, the machine will have its baptism of fire in three retrieval projects: searching literature in metallurgy, diabetes research, and communicable diseases.

The computer installation at the Documentation Center is the result of a five year study to mechanize the literature search. During this time the so-called "literature problem" has grown in magnitude. The number of technical articles appearing in the world is doubling about every eight years. In 1960, 1,300,000 articles were published in 60,000 publications. And new magazines appear at the rate of one every day.

What makes finding the significant references even tougher is that information retrieval is really more than just searching literature (see the diagram). It includes acquisition of the literature, translating (when an article is in a foreign language and about one third of the world's current output is written in Japanese, Russian, and Chinese), analyzing, abstracting, coding for storage, searching, and finally reproducing the applicable abstracts. Allen Kent, Associate Director at WRU's Documentation Center, says the Center spends $6.49 to acquire, translate, analyze, abstract, code, and store a single article on magnetic tape. And WRU's system is considered one of the more efficient ones in the U. S. Searching with the computer and reproducing the "found" abstract costs extra.

• **Finding a viewpoint**—The first thing that has to be resolved in information retrieval is how to store material so that a researcher with a viewpoint different from the man who stored it can find it. For example, a documentalist might read the article "Hydraulic Logic, What's Its Potential?" in the May issue of CONTROL ENGINEERING (p. 83) and code the abstract with such key words as *hy-*

draulics and *logic*. Later, if a researcher asks the system to find references on *multivibrators*, how can the system find this article which contains a description of an interesting and unique multivibrator?

To solve that dilemma, WRU has evolved an elaborate code dictionary which is stored on punched cards. This collection of synonyms, pseudo-synonyms, and related words is one of the most important elements in WRU's information retrieval system. So far, the Center has evolved only one such dictionary: for metallurgical literature (for use in a literature retrieval program sponsored by the American Society for Metals). Underway are the development of code dictionaries for literature retrieval in diabetes and communicable diseases.

The first step in information retrieval under the WRU system is to edit the researcher's question so that it is as meaningful as possible. For example, if an engineer wants references about how to use the Hall effect for measurement, he doesn't want every reference on measurement, nor does he want every reference on the Hall effect. And he doesn't want every reference on measuring the Hall effect. Key words in the edited question are then matched with the code dictionary and the output of this operation is the input for the computer search.

• **Needle in a haystack**—WRU's first efforts at machine searching were done on the electromechanical device shown on page 22. Here is how it worked. Abstracts in a telegraphic code were stored on punched paper tape. Key words selected from the code dictionary were wired in code by assigning relays to them. If, as the coded abstract ran through a tape reader, a key word was matched, the identification number of the abstract was printed out as well as the question number since the machine answers ten questions in a search.

But the WRU electromagnetic literature selector is slow: it can search only 30 abstracts an hour. That's why, in 1958, the Documentation Center asked computer manufacturers to submit bids for an electronic literature searcher. General Electric's proposal for a special purpose wired program computer, the GE 250, won the competition. As GE evolved the design for this machine, it found costs getting out of hand, finally persuaded the Documentation Center to install the GE 225 general purpose, stored-program, computer instead.

One of the most important aspects of using an electronic stored program computer was designing a program for literature search. GE and WRU researchers needed almost three years to develop the one for the GE 225 machine. Now WRU is trying to encourage other computer manufacturers to program their machines for information retrieval.

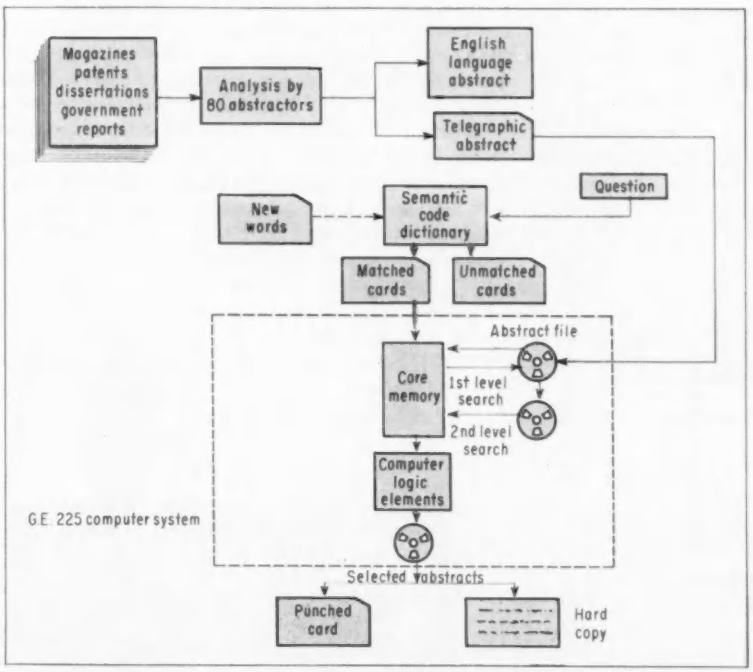
• **In levels**—Jack Belzer, the Documentation Center's computer specialist, has evolved a two level search program that speeds up hunting so the Documentation Center will be able to search its store of metallurgical literature (now at about 50,000 abstracts and growing at the rate of 39,000 per year), in about 35 minutes, answering 25 to 50 questions.

In the first search, the computer scans the magnetic taped abstracts looking for key words. This picks out 10 to 12 percent of the file quickly—almost at the speed the tape can move in the transport—and puts them on a second magnetic tape. The second search applies the logic to the 10 or 12 percent to isolate the few truly significant abstracts. For example, in the question already used as an illustration "How to use the Hall Effect for Measurement", the first search might find all references on measurement, Hall effect, and application. The second search would eliminate those abstracts that did not fit all three categories.

The secret to Belzer's technique is his assigning permanent storage areas in the 8,000 bit core memory to semantic factors. Each factor is a key four character word. As a result when the computer performs its search, it does not have to compare every word in the document with every word in the file. And logic is performed later.

• **Just a start**—As sophisticated as the WRU system looks, it is only a start. Associate Director Kent points out that only the search portion of the information retrieval process has been mechanized at the Documentation Center. Next: automatic abstractors and automatic translation.

At present, a good abstractor working on a part-time basis (WRU uses graduate students, public school teachers, internes, faculty wives, etc., to do the analysis and abstracting) can turn out about 10 a week. IBM, however, has experimented with a machine program called KWIC—keyword in context index—which will abstract and encode machine readable documents at a much faster rate, but based solely on the title. One still not completely satisfactory feature of KWIC is the requirement for a machine readable document. Most technical literature is acquired in the form of printed pages. Optical character recognition equipment is



Western Reserve's information retrieval system. Colored lines show a typical search.

one possible answer. Farrington Mfg. Co. has built a page reader for the U.S. Air Force that produces a punched tape output, and could be modified to produce a magnetic tape.

Automatic translation research programs are being studied widely.

▶Item. University of California has a $57,600 project to study machine translation of Russian literature in the field of biochemistry.

Item. Harvard University is investigating automatic translation of Russian into English.

▶Item. Massachusetts Institute of Technology is working on translating German into English by machine.

▶Item. In England, the Cambridge Language Research unit is doing basic research on new logico-mathematical methods for the analysis of languages for machine translation.

▶Item. The U.S. Army Signal Corps is sponsoring a German-to-English machine translation study at the University of Texas.

Other university machine translation projects: at University of Washington, scientific Russian into English; at Wayne State University, Russian mathematical journals into English; and at Georgetown University, Russian-English translation of organic chemistry texts and French-English translation of nuclear physics.

A flock of companies are working on automatic translation, too. Thompson Ramo Wooldridge, for example, aims to translate Russian physics literature on an IBM 704 computer. The Rand Corp., is also conducting research on the machine translation of physics texts.

At present complete automatic information retrieval is not feasible either technically or economically. But experimenters feel that, within five years, they'll have a working system that starts with an optical reader, then uses computer translation, computer abstracting, computer searching, and maybe even direct teletype communication to the information requester.

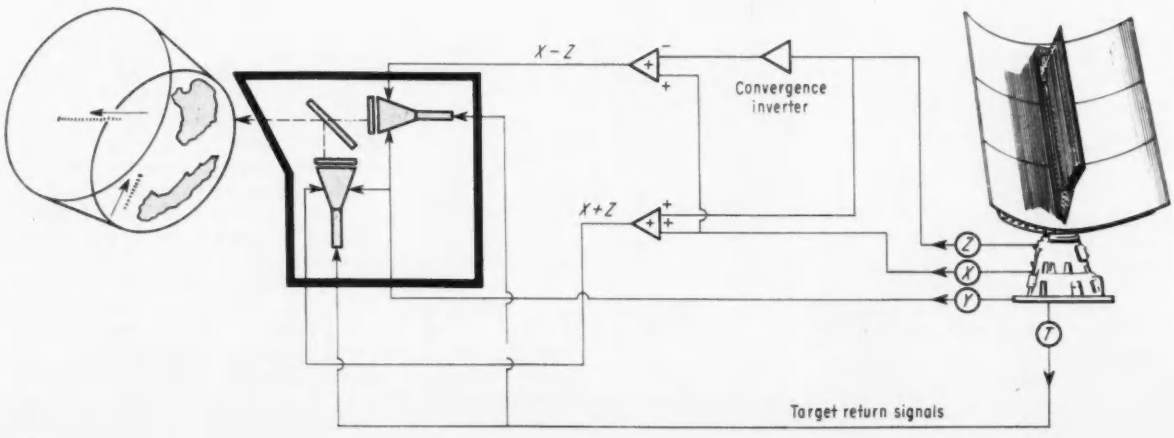
• **Buy a tape**—Just what kind of service the WRU GE 225 documentation center will provide is not yet completely determined. Through the ASM metallurgical information program, the most highly developed so far, an engineering researcher can order two types of search. He can ask for a retrospective search—all the literature on a specific subject in the documentation center's files. Or he can order a biweekly service through which, every two weeks, he'll receive abstracts of new literature that has been acquired in a specific area. Cost of a retrospective search of the literature for 1960 is $200. The biweekly service costs $50 per month.

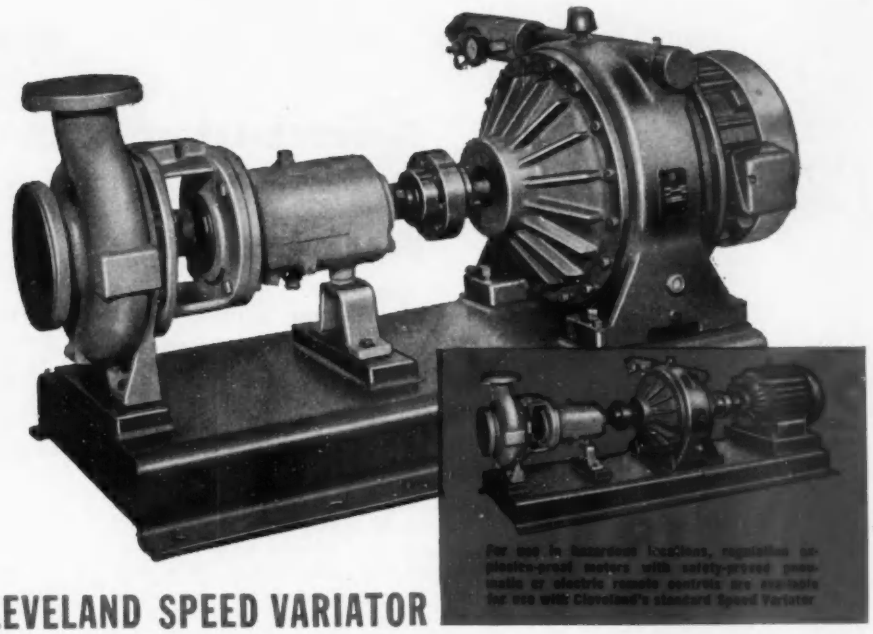
Eventually, what ASM would like to do is sell the magnetic tapes containing the abstracts. That way anybody who had a computer, with an information retrieval program, could search the literature. ASM has tentatively put a price of $10,000 on a year's collection of abstracts. Along with the tape, a customer would get the WRU code dictionary.

The WRU-ASM program is a model that large companies or other technical societies might well follow to set up information retrieval operations in other technical disciplines. The information retrieval demands on the GE 225 do not yet demand 100 percent of the computer's time, so the Documentation Center will serve as a computer service bureau for other university departments.

Electronic Three-D Radar Display

The stereoscopic display system, pictured below, was demonstrated last month by Hughes Aircraft Company, its designer and builder. With off-the-shelf hardware, it supplies a picture in depth of the track of aircraft as they move through the sky. In the demonstration, inputs were supplied by Frescan, the three-dimensional radar that Hughes has developed for the U.S. Army. To create the stereoscopic view, two Hughes Tonotrons are mounted at right angles directing their beams to a front surface, half-silvered mirror so that they appear to coincide when viewed by an observer. Polaroid filters in front of each tube and polaroid spectacles worn by the observer cause the information in one tube to be seen only by the left eye and the presentation on the other tube to be seen only by the right eye. Obvious application: air traffic control.





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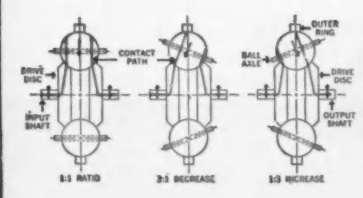


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Computer Control Stretches Synthetic Rubber Plant

Closed-loop analog computer control increases throughout and improves quality. Output of the amplifier is zero when density is on program.

HOUSTON—Since the synthetic rubber industry was founded as a war baby in 1940, process designers have relied almost entirely on manual control. Last month automatic control was introduced to Goodyear Tire & Rubber Co's. Plioflex plant here when an analog computer was installed to control the rubber-making operation. Goodyear expects to increase throughput and improve quality with the computer, which was specially designed for the plant by Goodyear Aircraft Corp.

• **Chain process**—In synthetic rubber making, the basic ingredients such as butadiene and styrene monomers are metered into the process in carefully measured proportions along with water solutions of soap, catalysts, activator and modifier. As the mixture moves through 12 chemical reactors, an oil-in-water emulsion forms and the monomers are converted to polymers, producing a suspension of rubber in water. To stop the reaction when the desired conversion has been reached—near the last reactor—controls inject a free-radical scavenging agent called a short stop.

When operated manually, a reactor-chain is run with standard pneumatic temperature and flow controllers: reactor temperature is held constant while flow stream recipe and reaction time are controlled. Cascaded expansion columns at the end of the reactor chain increase reaction time. The short stop flows into the column to control the percent conversion and stop the reaction.

Installation of a computer changes all that. Flow stream recipe is now held constant while reactor temperatures are changed. And the point of injection of short stop is also determined by the computer.

• **Gamma ray gages**—The key measurement in the rubber-making process is density—the density of the polymer output is much greater than the monomer raw material. And the density increases with increasing conversion. To generate an electrical signal compatible with the analog computer, Goodyear developed and installed a special gamma ray densitometer.

This instrument consists of a gamma ray source, a pipe containing the sample, a gamma ray detector, and an amplifier. It was the amplifier that turned out to be the most troublesome problem. First units had too much drift and were too noisy for good computer control. The model finally developed, a high-gain dc feedback amplifier, permits measurement of percent conversion to an accuracy of $\pm\frac{1}{2}$ percent. It is designed for high-stability conversion of the low-current output of a gamma ray detection unit into a signal usable in conventional electronic equipment.

• **Computer control**—The computer controls reactor output, flow stream recipe, and flow rate. Once the recipe control is set, total flow can be increased or decreased from one control dial and the computer maintains the selected recipe.

An optimum conversion rate for the unit has been calculated. Any deviation from this programmed rate along the reactor chain is detected by the gamma ray densitometers that generate error signals proportional to the amount of deviation. Output of the amplifier is zero when density is on program. From the error signals, the computer controls the temperature setpoints for the reactors.

When an error exists at a certain densitometer in the reactor chain, the computer feeds back temperature changes to reactors upstream of the density measuring gages to stop the generation of the error. Temperature changes are fed forward to reactors downstream of the densitometer to cancel the error as it passes through the next reactors.

When large upsets occur, the short stop injection point is switched to correct the conversion error.



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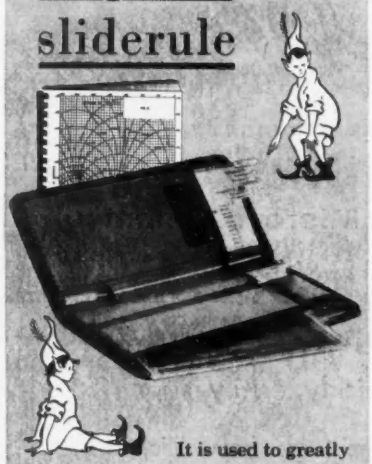
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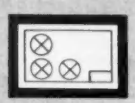
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JACC Sessions

WEDNESDAY, JUNE 28	THURSDAY, JUNE 29	FRIDAY, JUNE 30
MORNING	MORNING	MORNING
Session I — Formal Opening — Plenary Meeting	**Session V** — Optimal Switching I	**Session XI** — Adaptive Control Systems
	Session VI — Aerospace Vehicle Control I	**Session XII** — Nonlinear Control Systems
	Session VII — Process Dynamics	**Session XIII** — Statistical Design Considerations
AFTERNOON	AFTERNOON	AFTERNOON
Session II — Theory of Optimization	**Session VIII** — Optimal Switching II	**Session XIV** — Special Topics in Control
Session III — Hydraulic and Pneumatic Control	**Session IX** — Aerospace Vehicle Control II	**Session XV** — Process and Control Nonlinearities
Session IV — Economic Parameters in Process Control	**Session X** — Automatic Control Applications	**Session XVI** — Time Series and Process Identification

Economics and Optimums at Joint Control Conclave

The table above summarizes the sessions at the second annual Joint Automatic Control Conference, being held at the University of Colorado in Boulder, June 28, 29, and 30. Scanning the 55 formal papers and two invited presentations leads a control engineer to two conclusions: economics have attained a new stature in control systems engineering, and optimal controls and adaptive systems have lured the top control talent in the U.S. from other subjects.

In session IV, Harold Chestnut's (General Electric Co.) presentation "Cost Models for Systems Engineering" represents a new kind of paper written by a control engineer. It is indicative of a trend in which engineers find themselves more concerned with costs, something measurable in dollars, than technical variables such as response time. Chestnut will discuss mathematical expressions that have been developed to formulate online automatic control operating costs, and experience with their use.

• **Is it adaptive?**—The areas of adaptive and optimal controls are still controversial. Advocates of one approach or another hotly contest the offerings of others while staunchly defending their own. And the question of whether such controls even exist still plagues the industry. In session V, for example, L. Markus (University of Minnesota) and E. B. Lee (Minneapolis-Honeywell) will discuss the existence of optimum controls, reporting a mathematical tool to help an engineer determine whether an optimum system can be defined for the class of controls under study.

Despite the controversy, these two areas—adaptive and optimum controls—have drawn the greatest number of papers. There is a full session on optimization, one on adaptive systems, and two on optimal switching, a subject that continues to intrigue the control engineer. Some significant papers:

► **"An Adaptive Three-Mode Controller for the Process Industries"**, by W. B. Field, Union Carbide Olefins Co. An adaptive version of a noninteracting, linear, three mode controller permits a single function multiplier to adjust all controller modes with shifts in process dynamics.

► **"The Synthesis of Quasi-Stationary Optimum Nonlinear Control Systems"** by P. Chandaket and C. T. Leondes, University of California. An attempt to bridge the gap between theory and hardware in the "bang-bang" type of nonlinear control system. The technique helps the designer reach a quasi-optimum system.

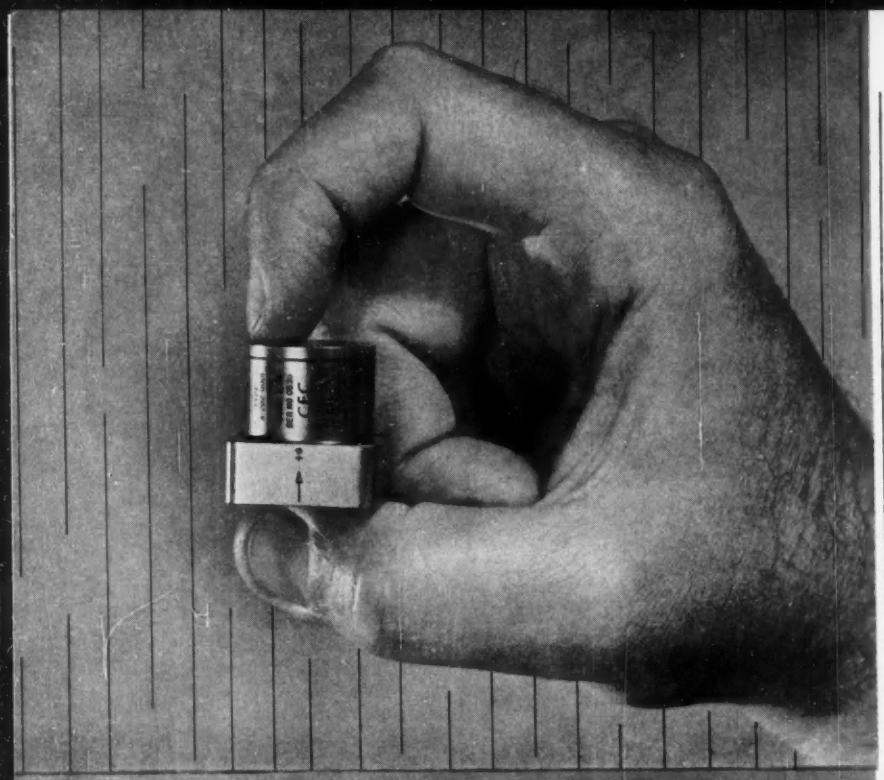
► **"Optimal Pursuit Strategies in Discrete-State Probabilistic Systems"** by J. H. Eaton and L. A. Zadeh, University of California. Another examination of the existence of optimum controls. In addition, the authors consider how to find an optimal policy



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Other technical areas that will be in the spotlight during the JACC meeting are noninteracting controllers, attitude control of space vehicles, and computer control. Some examples:

▶ **"Design of Non-Interacting Control Systems Using Bode Diagrams"** by K. Chen, R. A. Mathias, and D. M. Sauter, Westinghouse Research Laboratories.

▶ **"Can Electric Actuators meet Missile Control Requirements?"** G. C. Newton, Jr., and R. W. Rasche, MIT.

▶ **"Digital Computer Analysis of Closed-Loop Systems Using the Number Series Approach"** by R. K. Adams, Oak Ridge National Laboratory.

• **Fresh slant**—A new look at control is expected from the two invited speakers. M. L. Minsky, MIT, a mathematician who has concentrated on the theory of biological machines, will speak on the **"Neuristic Aspects of Adaptive Control".** Minsky is also a leader in heuristic programming, computer programs that incorporate some of the experience of an operator as "hunches".

K. Chen, Westinghouse Electric Corp., the second invited speaker, has surveyed automatic control research and finds that integrated control systems are the prime target for research. With integrated systems, Chen sees two developments: the need to close the gap between research and application (Chen's solution: put research people in close contact with application people on a specific project); and team design as opposed to design by an individual control engineer.

As Chen sees it, a single control engineer can no longer perform the whole synthesis and analysis of an integrated control. The team requires specialists in process analysis, or in instrumentation, or in computer hardware. He thinks there will be more interdisciplinary research to spark more creative thinking. And he predicts a closer relation between such subjects as biology and control and a tighter tie between econometrics and automatic control.

• **Disappointments**—Although the JACC program is an impressive one, there are some disappointments in it, indication that some of the less dramatic aspects are being pushed aside by the dramatic ones. For example, the program committee received few contributions on stochastic

← CIRCLE 30 ON READER SERVICE CARD

signals and processes or statistical methods in control.

What happens at JACC is significant because the conclave is the only integrated control meeting in the United States. The five sponsoring technical societies–ASME, ISA, IRE, AIEE, and AIChE–have agreed to hold no society meetings of their own solely on the subject of control.

New Labor Office to Ease Job Displacement

WASHINGTON—U.S. Department of Labor has established an Office of Automation and Manpower to study man power displacement caused by new technology and to uncover cures for resulting unemployment. The new organization is the one Secretary of Labor Arthur J. Goldberg promised to set up, after viewing unemployment in March (CtE, April, '61, p. 99, 100).

Goldberg named Seymour Wolfbein to head the new office. Wolfbein was deputy assistant secretary of labor and a manpower specialist.

In setting up the new office, Goldberg warned that automation, with all its benefits, means trouble ahead. He testified before a house labor subcommittee that machines and other technological developments would replace 1.8 million jobs in 1961.

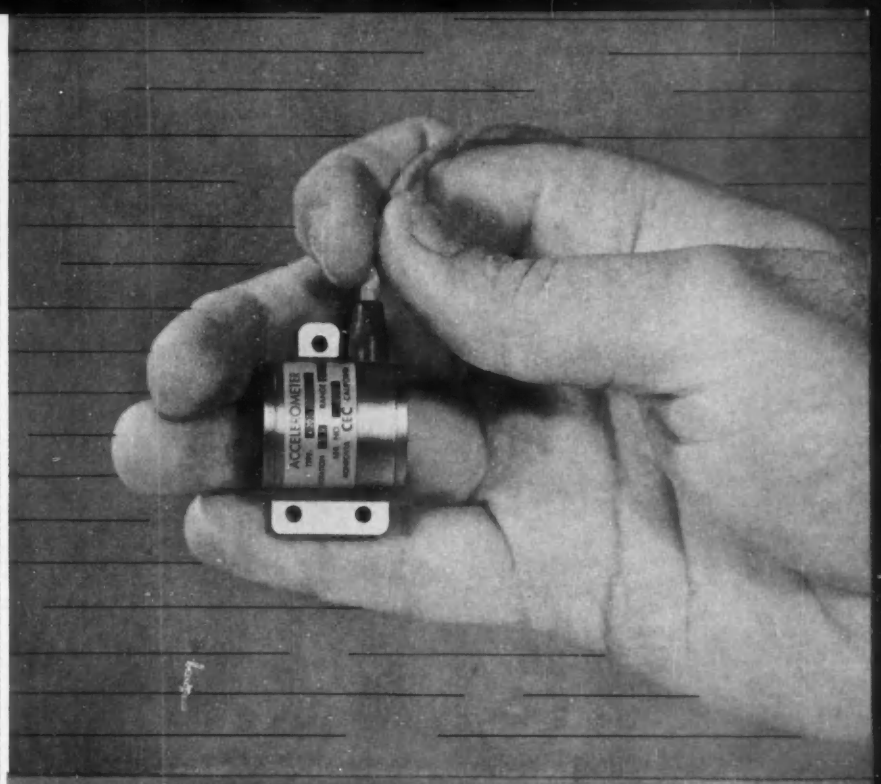
He told the subcommittee, headed by Rep. Elmer J. Holland (D., Pa., and a former union leader), "Nowhere in the Federal government has there existed an operational unit dealing with automation and manpower." He said that not only the federal government, but labor, management, and state and local governments have been "derelict" in their handling of automation.

Plans of the new division are threefold:

- ▶To survey the effects of automation on employment as well as unemployment.
- ▶To serve as a clearing house for automation data, developed from conferences with employers and workers affected by technological change.
- ▶To provide specific help for displaced employees through federal-state employment agencies and the Bureau of Apprenticeship by relocating, training, and retraining for new jobs.

Wolfbein's new division also plans to predict what areas automation will affect. For example, he sees electronic computers for automatic data processing seriously reducing the number of white collar workers in the next few years.

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Count on sensational performance from the newest addition to CEC's family of strain gage accelerometers! Type 4-203 packs all the superior performance characteristics of earlier models into just one cubic inch and less than three ounces.

Available in ranges from ±5g to ±500g, the 4-203 operates in a temperature range of –65°F. to +250°F.

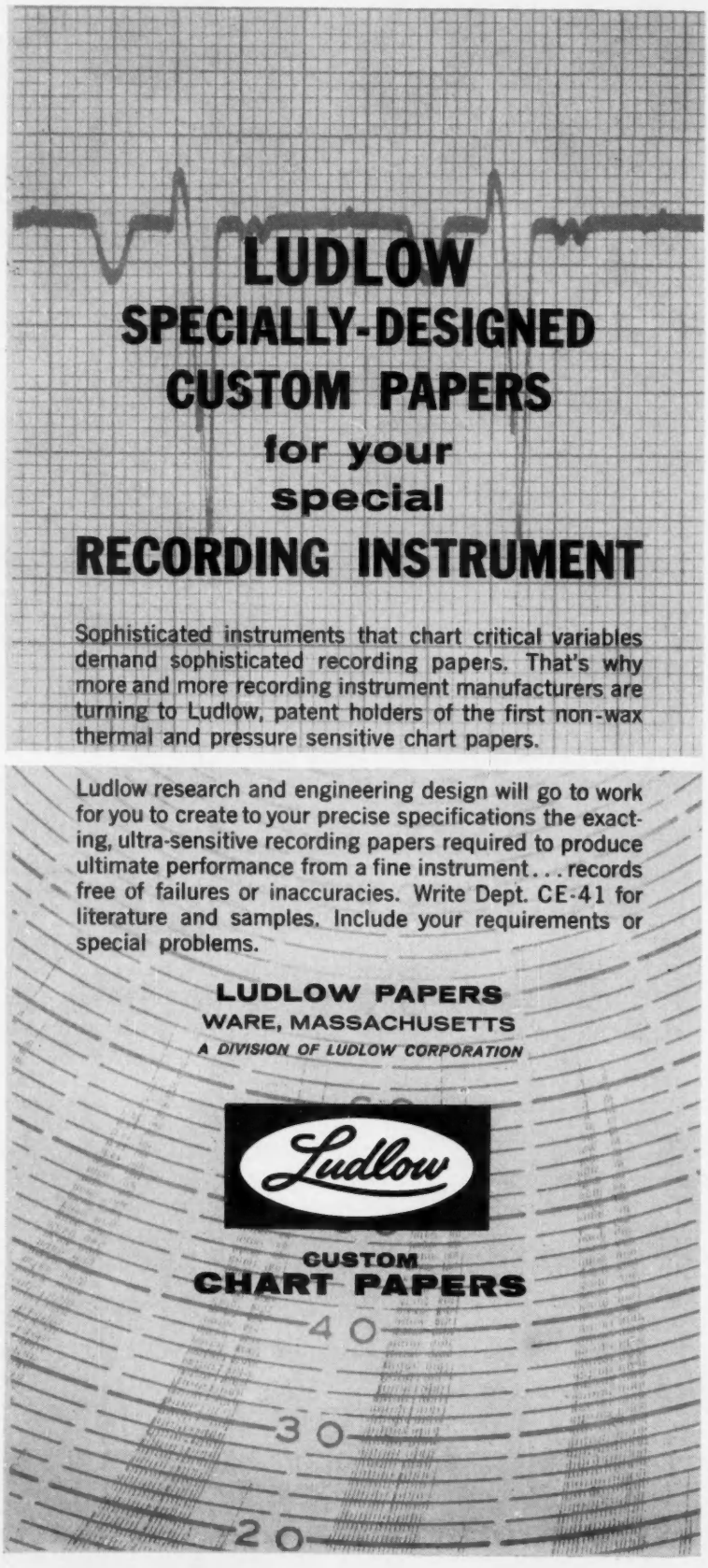
In accurately measuring accelerations parallel to mounting surfaces, this miniature instrument performs with the lowest cross axis response... the smallest damping change with temperature... and the highest resonant frequency of any comparable instrument available.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 4203-X5.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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REPORT FROM JAPAN

The Economy Thrives on Automatic Control

CtE's Japanese correspondent, Kazuto Togino, visiting for a year at the U.S.'s Case Institute of Technology reports how his country's economy has reacted to the installation of automatic controls.

The application of automatic control in Japanese industry is creating new jobs and raising the standard of living. This happy condition has developed despite strong labor opposition and engineers' doubts that Japanese industry would ever trade its low paid human work force for automatic control.

Japan has solved the labor displacement problem so far. Workers have been absorbed by their own companies in other jobs or by other companies. For the past ten years Japan has not been plagued by serious unemployment. And Japan's economic health has continued to improve.

One reason that modernization with automatic controls has proceeded so smoothly is that Japan has enjoyed a boom since 1950. Steel and chemical industries—both big users of instrumentation—have benefited heavily from the period of good business. To boost capacities they've relied on mechanization and modernization, not construction.

Expansion in these two industries has provided a base on which Japanese instrument and control makers have grown. And the expansion continues. Japanese economists expect the steel industry, for example, to triple over the next 50 years. For the future, control and instrument suppliers can expect their customers to continue heavy emphasis on improving efficiency and cutting costs rather than building new plants and facilities.

One of the most exciting modernization movements in Japan is the application of digital computers to improve production processes. Japan got a late start in computer development, but the number of domestic-designed machines now available indicates the great interest in this area. There are 24 different transistorized designs and 10 different machines with parametron circuitry.

In addition, Japanese companies have been big importers of U.S. designed machines. IBM, Sperry-Rand, Librascope, and Bendix have all sold computers in Japan, primarily for business data processing, although

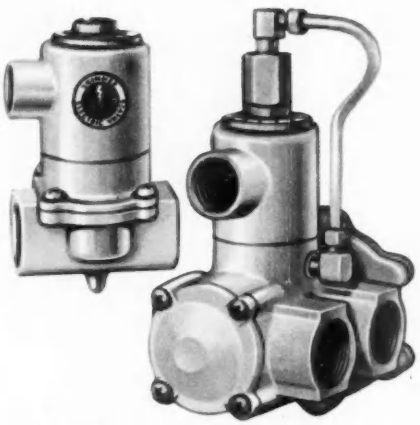


SKINNER EXPLOSION-PROOF SOLENOID VALVES

Skinner has a complete range of Explosion-Proof Solenoid Valves

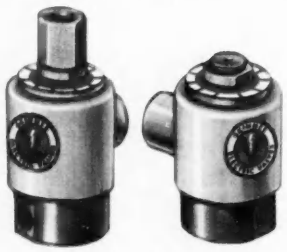
If you have a control problem involving valves operating in hazardous locations—Class I Group D (gasoline vapors, etc.), Class II Group F (coal and coke dust) and Group G (grain dust)—you can select from Skinner's complete line of two- and three-way explosion-proof standard and high pressure solenoid valves.

- **U.L. approved**
- **A wide range of pressure ratings and orifice sizes**
- **Bodies and coil housings machined to close tolerances—clearance is 0.0005**
- **Stainless steel or naval brass bodies**
- **Stainless steel internal parts**
- **Stainless steel and brass internal parts**



STAINLESS STEEL TWO- AND THREE-WAY SOLENOID VALVES—X5 SERIES

The highest quality and most versatile valves manufactured. So flexible that basic valve can be modified to provide porting, mounting, or flow-control, to meet most applications.



Two-way solenoid valves are available normally closed, normally open and dual purpose. Orifice sizes from 1/32″ to 3/8″, maximum operating pressure differential 3000 PSI depending on orifice size—NPT pipe size 1/8″, 1/4″ and 3/8″.

Three-way available normally closed, normally open, directional control and multi-purpose. Orifice sizes from 3/64″ to 1/4″, maximum operating pressure differential 200 PSI depending on orifice size.

TWO-WAY PISTON TYPE SOLENOID VALVES—XR SERIES

These valves, with forged naval brass body and stainless steel piston, handle high flow and high pressure requirements of industrial and commercial applications with most common media.



XR series valves are available with 1/4″ orifice and 1/4″ NPTF in normally closed or normally open construction. Operating pressure differential 5 to 1250 PSI for AC operation and 5 to 1000 PSI for DC operation.

TWO- AND THREE-WAY HIGH FLOW SOLENOID VALVES—XL SERIES

These diaphragm type solenoid valves meet the high flow requirements of a great many commercial and industrial applications. The unique Skinner diaphragm construction makes possible the exceptionally long service life of this series valves.

Two-way XL series valves are available normally closed and normally open. Orifice sizes are 1/2″, 3/4″ and 1″ with corresponding NPTF pipe connections. The 1/2″ orifice model is also available with 3/8″ NPTF. Operating pressure differential is 5 to 150 PSI.

Three-way XL series valves are available normally closed, normally open and directional control. Orifice sizes are 3/8″, 1/2″ and 3/4″ with corresponding NPTF pipe connections. Operating pressure differential is 5 to 150 PSI for the 1/2″ and 3/4″ size and 10 to 150 PSI for the 3/8″ size.

TWO- AND THREE-WAY HIGH PRESSURE HYDRAULIC SOLENOID VALVES—X10 SERIES

These stainless steel, direct acting, slide-type valves are precision engineered to control hydraulic systems at pressures up to 2000 PSI.

These high pressure hydraulic valves have a 3/32″ inlet and cylinder orifices with 1/8″ NPT. They can be used as two-way normally closed or two-way



normally open valves by plugging the appropriate port, and three-way normally closed, or three-way normally open, or dual purpose valves.

• • •

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

WHAT'S NEW

. . . in Japan, a shortage of control engineers is likely to slow up computer control . . .

a few have logged data, accumulated data, monitored plant variables or calculated efficiencies or operating guides for processes.

Today, most Japanese control hardware makers are expanding to meet an expected large market in digital devices that will be required in the modernization by computer of the continuous processing industries.

Program control of rolling mills in steel plants, of conveyors, and of machine tools is already installed in Japanese facilities. Several hundred data loggers are in the chemical industry. Computer installations to control inventory or to compute operating guides for static optimization have been planned. The next step is closed-loop computing control.

This next step is likely to take longer than you would expect, considering the rapid progress Japan has made up to now. But the shortage of qualified control engineers is likely to slow the design of such large systems.

Of Japan's 140 national and private universities, with enrollments of over 100,000, only 20 universities train control engineers. And these turn out no more than 200 qualified men per year. Fortunately the number has been swollen by graduates with degrees in electrical, chemical, and mechanical engineering, electronics, and science who specialize in control after taking a few basic courses such as servomechanisms, process dynamics, theory of process control, theory of automatic control, and control elements during their academic career.

Several companies have offered short courses in control to alleviate the shortage. One manufacturer of presses offers its engineers 5 courses in control a year. The courses normally draw at least 150 students.

In Japan, almost everybody is willing and eager to take extra training. Employers are agreeable about sending their workers to such courses. Many of the short courses are planned so that beginners can participate in them, and progress in control studies.

Modernization in Japan is going to continue at about the same rate maintained over the past five years. It now seems certain that no Japanese company is going to employ 1,000 operators of desk calculators because of their low labor rate, when the firm can use a digital computer instead.

—Kazuto Togino

motorability since 1942



Kollsman has been designing and manufacturing special-purpose control motors of high precision for 19 years. More than 1,000 different Kollsman-designed motors now exist.

Our Sales Engineers will be glad to consider your motor problems without obligation. Because of our tremendous backlog of existing designs most likely we can select the answer to your requirements immediately. If not, we are equipped and staffed to design to your specification.



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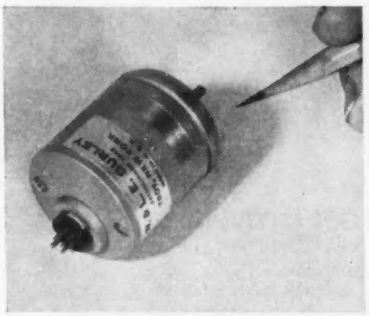


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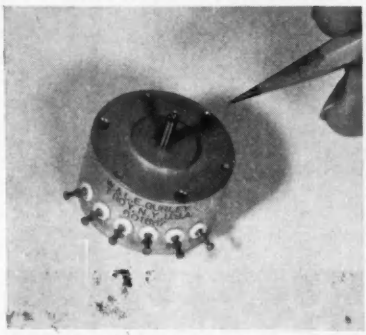
GURLEY Photoelectric PULSE GENERATORS Add...Subtract...Count

Gurley photoelectric pulse generators are shaft-driven, delivering electrical pulses at terminals. Pulse frequency is directly proportional to shaft speed; and pulse amplitude is independent of shaft speed. **Used basically as rate generators or as angle-measuring devices.** All models available with direction-sensing photo cells.



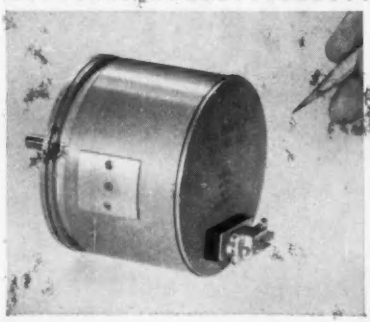
Model 8601

Synchro Mount ..... 1.437" dia.
Length ..... 1.875"
Up to 1024 apertures
Inertia ..... 2.8 Gm-Cm²
Torque ..... less than 0.1 in.-oz.



Model 8602

Housing Diameter ..... 1.375"
Length ..... .844"
Up to 1024 apertures
Inertia ..... 2.8 Gm-Cm²
Torque ..... less than 0.1 in.-oz.

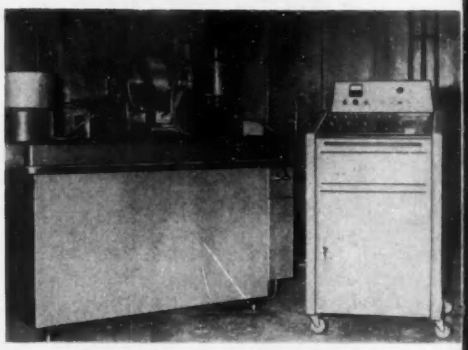


Model 8603

Synchro Mount ..... 3.4" dia.
Length ..... 2.6"
Up to 5000 apertures
Inertia ..... 340 Gm-Cm²
Torque ..... less than 0.1 in.-oz.
Built-in amplifiers available.

Write for information on one or all.

W. & L. E. GURLEY, TROY, N. Y.
537 Fulton Street



Most Accurate Contouring System

Hydraulic feedforward and a new servo valve design make a Dutch cam miller the most accurate numerically controlled machine tool in the world.

EINDHOVEN, HOLLAND—At the Philips Research Laboratories here, a cam miller with a digital-hydraulic continuous contouring system produces a profiled cam whose machined surfaces are accurate to 2.5 microns (0.00012 in.). The machine shapes the high accuracy cams needed to run automatic machines to wind vacuum tube grids precisely, maintaining specified grid-space ratios, at the rate of one per hour. Because of the unique design, the mill's control system has an over-all deadzone of only 0.1 to 0.3 microns and system bandwidth exceeds 100 cps.

This unusual approach was developed by T. Viersma, who earned a doctorate degree with it at Holland's Delft Technological University. His basic philosophy is to maintain the system's forward path as independent of error as possible so that only limited feedback is needed to cancel the residual error. To do this Viersma had to minimize two common errors in hydraulic numerical control systems: 1) those caused by high system velocity time constants and 2) those resulting from positional variations as loads on the machine change.

• **In turbulent flow**—To attain a low velocity time constant in the system that drives the table slide, the Dutch control engineer specified that the valves and servomotors operate in a range of turbulent flow, by ensuring a Reynolds number of the port flow greater than 20. Under these conditions, flow rate is independent of port width—and even more important, flow rate is independent of viscosity and

New! Sylvania CT4251

First

Compact
Decade Counter Tube
in Dome-Shaped T-9 Bulb
with 10 Output Cathodes



Illustration compares size advantage of Sylvania CT4251 to type in T-11 outline

Sylvania introduces the new CT4251 . . . opening a dramatic new approach to the design of very compact, low-cost counting equipment in the 0-50KC frequency range.

Utilizing a new dome-shaped T-9 bulb evacuated from the base, Sylvania CT4251 offers significant reductions in seated height. CT4251 features 10 output cathodes, offering the versatility and advantages of tube types previously available only in the T-11 bulb. Examples: electrical information can be fed from all 10 cathodes, enabling preselection of a count from 0-9; the diameter of the ring of cathodes is identical with that of types in the T-11 outline, providing excellent visibility of readout information.

Sylvania CT4251 is the lowest cost *cold cathode Decade Counter Tube* available. Combining electrical and visual readout functions, it offers extensive economies in circuitry and associated components. Sockets, too, for its 13-pin circle are as much as one-half the cost of sockets normally required for T-11 types. In addition, this new 13-pin circle makes it possible for Sylvania CT4251 to be designed into equipment using transistorized and printed circuit techniques.

Tests to date of Sylvania CT4251 indicate superior quality performance even under stand-by operation for 500 hours.

Your Sylvania Sales Engineer will be pleased to tell you more. Contact him or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 136, 1100 Main St., Buffalo 9, N.Y.

Sylvania Type	Total Anode Current (mA)		Min. Anode Supply Voltage (Vdc)	Min. Double Pulse Amplitude (V)	Min. Double Pulse Width (μsec)
	Min.	Max.			
CT4251	0.65	0.8	400	−70	4

SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 37 ON READER SERVICE CARD



What's new about this Primary Pressure Standard?

TWO THINGS. Continuing engineering studies have produced two remarkable improvements in the performance of CEC's Type 6-201 Primary Pressure Standard.

First: resolution has been improved to 0.002% of reading. Second: new and greater accuracy is 0.015% of *reading* in ranges to 150 psi and 0.025% of *reading* in ranges of 150 to 500 psi. (Both percentages formerly were *full scale.*)

Accuracy in the calibration of gage or absolute pressure measuring instruments – such as CEC's new Miniature Electromanometer System – begins with the 6-201. This pneumatic deadweight piston gage covers six pressure ranges from 1.5 to 500 psi. A portable, true primary standard, the 6-201 utilizes mass, length and time for its references. Accuracy depends only upon the dimensional accuracy of its component parts.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 1581-X34.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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WHAT'S NEW

. . . a valve port made by two sharp knife edges; a compensating orifice in servomotor . . .

temperature. At first glance, turbulent flow doubles the effective time constant, but Viersma compensated for this by increasing oil flow through the ports.

Turbulent flow is assured by the servovalves. A new design was dictated by the demand for an open center type with port widths underlapping the valve spool neutral position and designed so that no boundary layer of oil can form to slow the flow and thus increase the velocity time constant. Viersma's valve has ports formed by cylindrical slits between two knife edges. Because there is no sliding contact between the knife edges—since even in the minimum position flow continues through the port—the valve is nonwearing.

One factor that turned out to be important in valve performance is the sharpness of the knife edges. In an experiment, valve velocity time constant was about four milliseconds when the knife edges were sharp, with a radius of about 10 microns; time constant tripled (to 12 milliseconds) when the edges were rounded to a 30 micron radius.

• **Feedforward**—To compensate for changes of loading on the servomotor, a special compensating orifice in the motor cancels pressure variations caused by loading changes. In the servomotor, the ram has a flexible membrane which forms the compensating orifice to change oil flow.

Here is how it works. If the loading on the ram suddenly increases, pressure builds up on the reservoir side, increasing flow through the spool valve. At the same time, the increase in pressure deflects the membrane on the ram enough so that flow through the compensation port increases the same amount as flow increased through the spool valve. Even when the load changes, the ram is stationary. Increased hydraulic rigidity prevents servomotor deadband.

• **Punched tape control**—During a cut the workpiece rotates at uniform speed and its angular position is measured. This information along with input from an eight channel punched tape (cutter feed speed and acceleration for each trajectory) allows a computer to calculate the required position for the cutter slide. When the calculated position is compared to the actual position, the resulting error signal is used to reposition the slide. So only one feedback is required

←CIRCLE 38 ON READER SERVICE CARD

to follow a two-dimensional contour.

Inside the computer, one register holds the desired values of slide position, another holds speed, and a third retains the acceleration for each trajectory to be milled. As the turntable rotates, a disc and photocell system generate synchronizing pulses every 3.5 seconds of arc. At each synchronizing pulse, the contents of the acceleration register is added to the speed register. The speed register is then added to the position register to produce a linear interpolation of slide position between points. Overflow of the position register generates a positive or negative command pulse that orders a 1.25 micron slide displacement in one direction or the other.

Slide position is measured by a Moire fringe optical grating system. It produces a pulse for each 1.25 microns of movement.

A 15-step bidirectional counter serves as a digital-to-analog converter. It takes command and position pulses and converts them to a control current that depends on the position of the counter. The control current drives a servovalve that controls the hydraulic ram to which the slide is attached.

—Derek Barlow

Electrical Output Runs New Station's Fuel Supply

LONDON—

Britain's new 200 megawatt generating station at West Thurrock (Essex) will not only be the first in Britain with computer control for automatic startup and shutdown but also the first to include the boiler-turbine unit within the main control loop. In the loop being instrumented by Evershed and Vignoles, the station's megawatt output directly controls the fuel input to the boilers. Previous practice: fuel input is regulated by boiler heat output.

At West Thurrock, after signals representing actual power station load are corrected for boiler pressure, air-steam ratio, and furnace pressure, they regulate the pulverizing mill and draft fan operations.

Special wide range transmitters are switched in by the computer for automatic startup and shutdown. When running conditions are reached, these transmitters are automatically switched over to high sensitivity limited span units that cover only the normal working range. Resetting signals for three term controllers on the process are also generated by the computers during startup and shutdown.

CIRCLE 39 ON READER SERVICE CARD→



What's new about this Secondary Pressure Standard?

EVERYTHING. CEC's Miniature Electromanometer System is all new. Either of its two components can be held in the palm of your hand.

Its Type 4-333 Precision Pressure Balance is designed to measure differential, gage and absolute pressures to 100 psi. The system's Type 1-156 Servo Amplifier is 100% solid-state in design and is fabricated on circuit card modules. It includes an integral power supply for operation on 115v, 60 cps line voltage. A multi-channel adapter, available as an accessory for the system, can be used as a switching unit for two to six pressure balances sharing a single servo amplifier.

This precise new CEC system provides secondary pressure standard accuracies for laboratory, field or industrial applications ranging from process control to calibration service. Its small size and high-level output assure easy integration into major system designs.

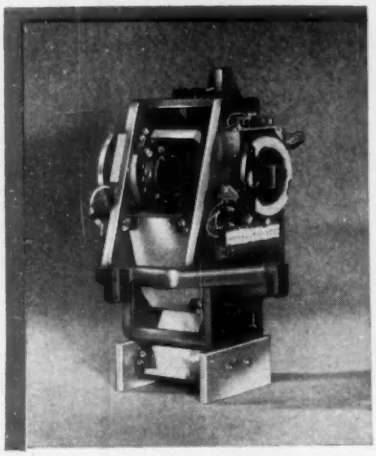
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Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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PRECISE STAR TRACKER



A celestial navigation system called for a tracking device capable of establishing a line of position within an accuracy of 300 feet. Kollmorgen came up with a constant deviation elevation system that positions a movable mirror, in relation to the fixed elements, to a repeatable accuracy of better than 5 parts in a million.

This compact package represents a combination of highly precise optical and electronic units in a housing only 6 x 6 x 10 inches. Kollmorgen's project from concept to installation, it is a typical demonstration of the company's scientific, engineering and manufacturing skills in optics, electronics, mechanics. Example: the precision optics (a prism and two mirrors) are of Kollmorgen manufacture. So, too, are the Inland torque motor*, the gearing and other precision-machined parts.

Our motive in this message: Kollmorgen offers proven capabilities in optics, electronics and precision machining of metal components . . . capabilities which could solve your problems in missile tracking, fire controls, navigation, or . . .?

Present us with a problem.

*Product of Inland Motor Corporation of Virginia, a Kollmorgen subsidiary.

Dept. 5-6

KOLLMORGEN CORPORATION
NORTHAMPTON, MASSACHUSETTS



LING: ". . . must have growing momentum . . . and be able to do $200,000 in 12-18 months . . ."

McKINNEY: ". . . most SBIC's are not staffed to offer technological sales aid . . ."

Modern Money Tree

Small Business Investment Companies can help the struggling control company get started. Here is how Electro-Science Investors works. Under the hand of dynamic, 39-year old James J. Ling, it has become one of the fastest growing investment firms. In seven months it has invested over $7 million in eight electronics-control companies, is screening 30 more per month.

DALLAS—

One of the biggest problems facing idea-rich but money-poor young engineers today is how to finance a new company to turn a profit on their inventions. New, small firms are simply not big or reliable enough to shop for capital in the usual money markets. And the national security exchanges are restricted to financing well developed companies. Recognizing this problem, the government's Small Business Administration set up the Small Business Investment Company system late in 1958 (CtE, Dec. '58, p. 120). SBIC's can loan money to the small companies that cannot qualify for loans from the usual sources. One of the newest and fastest growing of these SBA-administered SBIC's is Dallas' Electro-Science Investors, Inc.

ESI was started last October by James J. Ling, left above, who besides pulling together a vast aircraft-electronics empire through mergers and acquisitions—Ling Electronics, Temco Aircraft, and now Chance Vought (CtE, May '61, p. 187)—is ESI's biggest stockholder (34.3 percent) and board chairman. President is 30-year-old Joseph F. McKinney, right above, who with Ling launched the company.

• **How it picks 'em**–Since October ESI has invested $7.05 million in eight of what it terms "partner" companies. It screens and analyzes over 30 companies each month, but few of the offerings make the grade. How does ESI pick its investments? Here are some of its yardsticks:

▶ First, ESI puts most of its dollars into the controls and instrumentation end of the electronics industry. "We believe this is where financial help is most needed," says McKinney. And the growth prospects are best. "We think the electronics industry will double its present sales in the next five years. Controls and instrumentation will account for much of this, and we want in."

▶ The company must have "growing momentum". A firm with just ideas but no actual prototypes or production is not usually considered.

▶ The company must have capabilities of doing at least $200,000 business annually within 12-18 months.

▶ The company must need more than money. ESI wants those seeking capital plus management assistance.

McKinney explains this last point this way. "We feel most SBIC's are not professionally staffed; they offer



Alexander M. Poniatoff, Founder and Chairman of the Board of Ampex Corporation, discusses magnetic tape recorders.

How to get accurate data on a small recorder

Ampex's new CP-100 nicely balances four desirable qualities

Compact. Definitely, and a great advantage in trailers, in airplanes, in submarines, or even in regular laboratory use. There's complete front access to everything. All-transistor amplifiers and power supplies cut power needs and keep down the heat – an advantage in tight equipment layouts.

Portable. We'll frankly admit it takes two men to carry it – not just one and a half. But by calling in an occasional fractional man (or by using an accessory dolly) you gain exactly the needed performance that portables have lacked until now. In laboratory use, the CP-100 is "bench-top equipment."

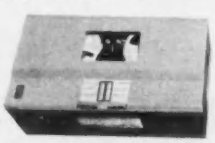
Precise. Let the numbers talk. Though compact, the CP-100 is a full-fledged, uncompromised laboratory recorder: 200 kc response at 60 ips tape speed (and proportional at others); flutter well within telemetered data requirements; intermodulation distortion so low it never adds spurious data of its own.

Universal. Yes, in numerous ways. The CP-100 isn't fussy about power; takes 115 or 230-volt AC at 50, 60 or 400 cycles or 28-volt DC from batteries or generator. Kinds of data: direct or FM-carrier, by interchangeable plug-in amplifiers. And it records and plays back as well.

The essential data

Model: CP-100 Compact Recorder/Reproducer. *Reel size and tape width:* 10½-inch reels with ½- or 1-inch tape (as specified). *Types of recording:* direct or FM carrier by plug-in interchangeable amplifiers. *Tape speeds:* 60, 30, 15, 7½, 3¾ and 1⅞ ips. *Frequency response:* direct, 300 to 200,000 cps ± 3 db at 60 ips; FM carrier, 0 to 20,000 cps at 60 ips; response at other speeds proportionate. *Tape compatibility:* yes, with Ampex FR-600, AR-200 or interchangeable with FR-100, FR-1100, 300 and 800 series.

May we tell you more? Please write



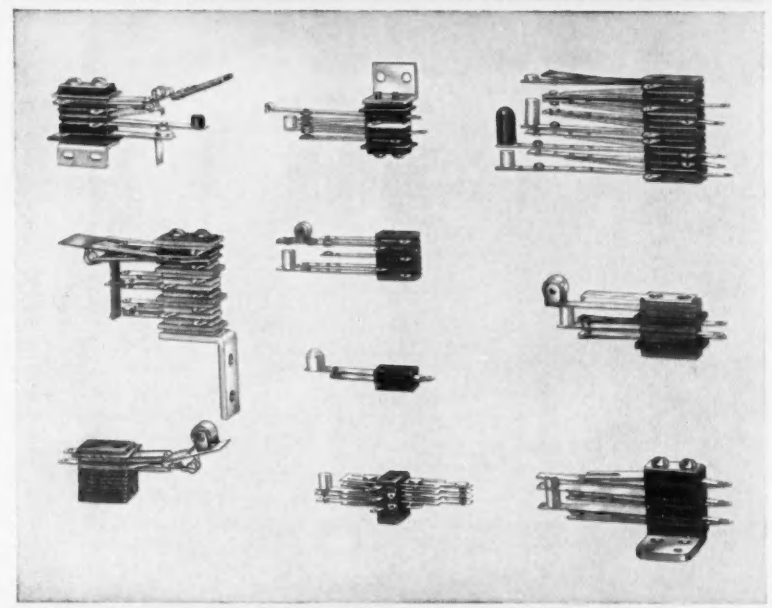
AMPEX

AMPEX INSTRUMENTATION PRODUCTS CO.

Box 5000 • Redwood City, California • EMerson 9-7111

CIRCLE 41 ON READER SERVICE CARD

EVERYTHING UNDER CONTROL *with*
GUARDIAN® SWITCHES



Realistic photographic reproductions portray a wide variety of Guardian switches including leaf, snap-action, cam, roller, coin, bifurcated, push button, special switch assemblies, among others.

These basic designs suggest thousands of combinations available as standard or custom-built switches to meet your exact needs.



We invite you to write for your copy of this new Guardian 16-page Switch Catalog just off the press.

Complete dimensional drawings of all switch components are included.

Write on your company letterhead for catalog "E"

GUARDIAN ELECTRIC
MANUFACTURING COMPANY
1558-G W. CARROLL AVENUE, CHICAGO 7, ILLINOIS

WHAT'S NEW

financing and nothing else. We have shareholders and employees who can and do offer technological, management, sales, and other aid."

ESI's management group, besides Ling and McKinney, includes three top vice-presidents: Raymond E. Jacobson, Paul E. Brodrick, and Royce B. McKinley.

Ling has been described by some as one of the most expert in the country at sizing up a company. McKinney has an investment background, having been with investment bankers and dealers in the east. He is also a director of Missile Systems Corp.

Jacobson has graduate degrees in both engineering and economics. Before joining ESI he worked in research, design, development, and manufacturing at Thompson-Ramo-Wooldridge Products Co. He also did sales and research work for Curtiss-Wright's Electronics Div.

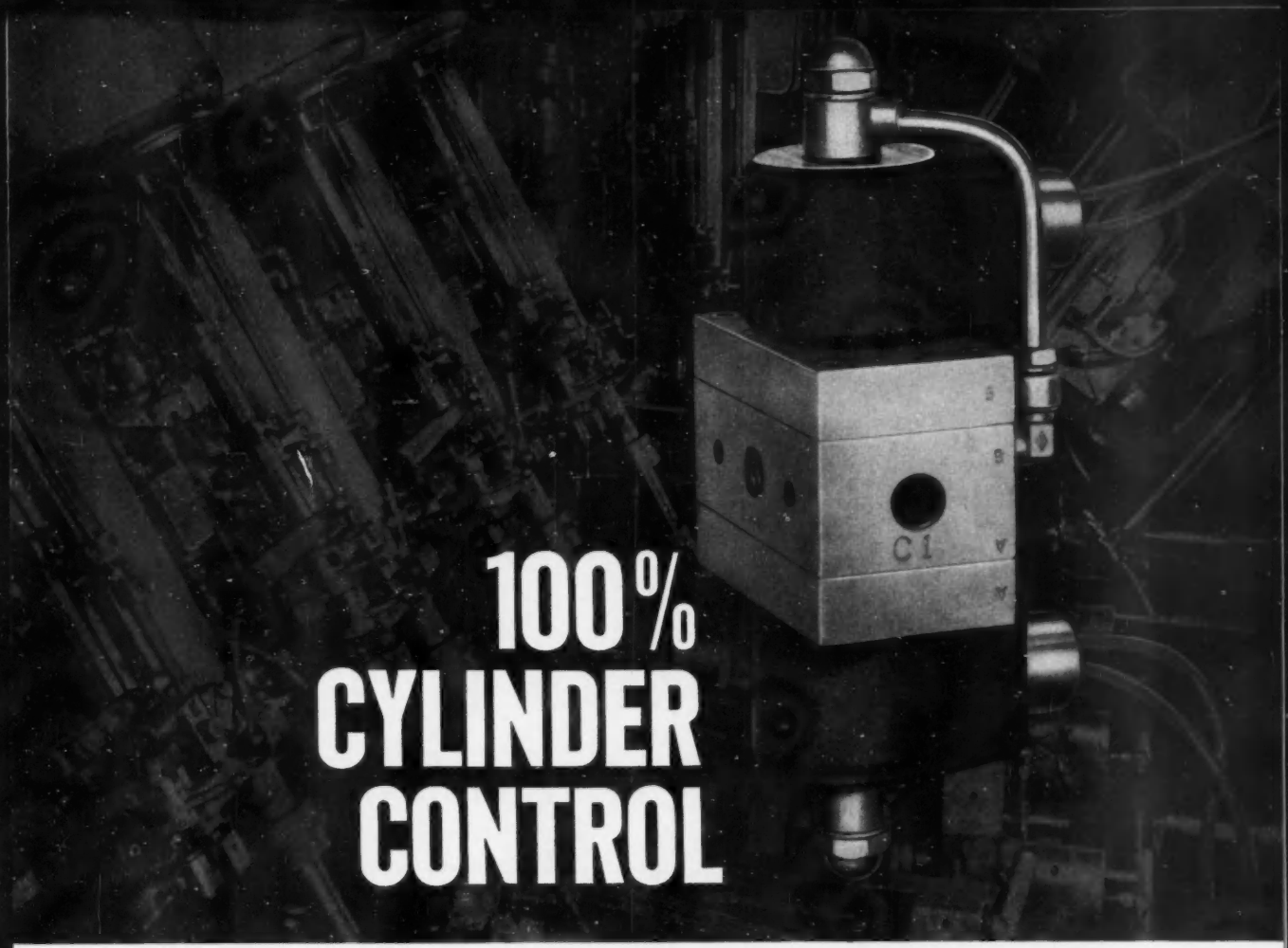
Brodrick analyzed and appraised companies being considered for acquisition by Dresser Industries; his education is in economics. McKinley was with a management consultant firm and specialized in general corporation surveys, management organization, and merger and acquisition studies.

• **Hot tips**—To start the firm McKinney and Ling raised $7.5 million from 25 selected investors. After a public stock offering ESI had raised $15 million cash. At first the founders themselves supplied the leads on good investment possibilities. Now other professional people, who have become stockholders, make recommendations too. "The thing has snowballed," says McKinney. "We have bird-dogs out all over the country."

McKinney and his group run down the tips and screen the good possibilities. McKinney estimates there are over 8,000 small electronics and allied firms in the county—"the market is tremendous for an investment firm like ours."

Many possible investments are eliminated before they ever get to the serious screening stage. Since ESI's start last fall, only one company in 30 has made a deal.

• **Looking for control?**—One question that has to be answered in using money this way is who gains control of the borrowing company. The question frequently turns into a financial stumbling block because the owners of a company are reluctant to give up stock control to a financial group such as ESI. ESI has obtained a substantial interest in each of the companies



100% CYLINDER CONTROL

DEAD-TIGHT SEATING OF ASCO 4-WAY SOLENOID VALVE PREVENTS PISTON DRIFT ...PERMITS PRECISION INCHING

3-POSITION, 4-WAY DESIGN

POPPET-TYPE SEATING— CANNOT STICK OR LEAK

INSTANTANEOUS OPERATION

EXPLOSION-PROOF ENCLOSURE AVAILABLE

PRESSURES UP TO 250 PSI ON AIR, WATER OR OIL

RUGGED BRASS BAR STOCK

2 SOLENOID CORES AND 4 DIAPHRAGMS ARE ONLY MOVING PARTS

Positive control of the cylinder piston is inherent in the design of this ASCO Bulletin 8347 valve. Leakage of air or liquid is made impossible, so that whenever both solenoids are de-energized, the valve assumes a center position and all orifices are blocked, locking cylinder piston in position. Dead-tight (poppet-type) valve seating permits precision inching of the piston, as well as absolute control of any length of stroke, with instantaneous stopping and not a trace of drift.

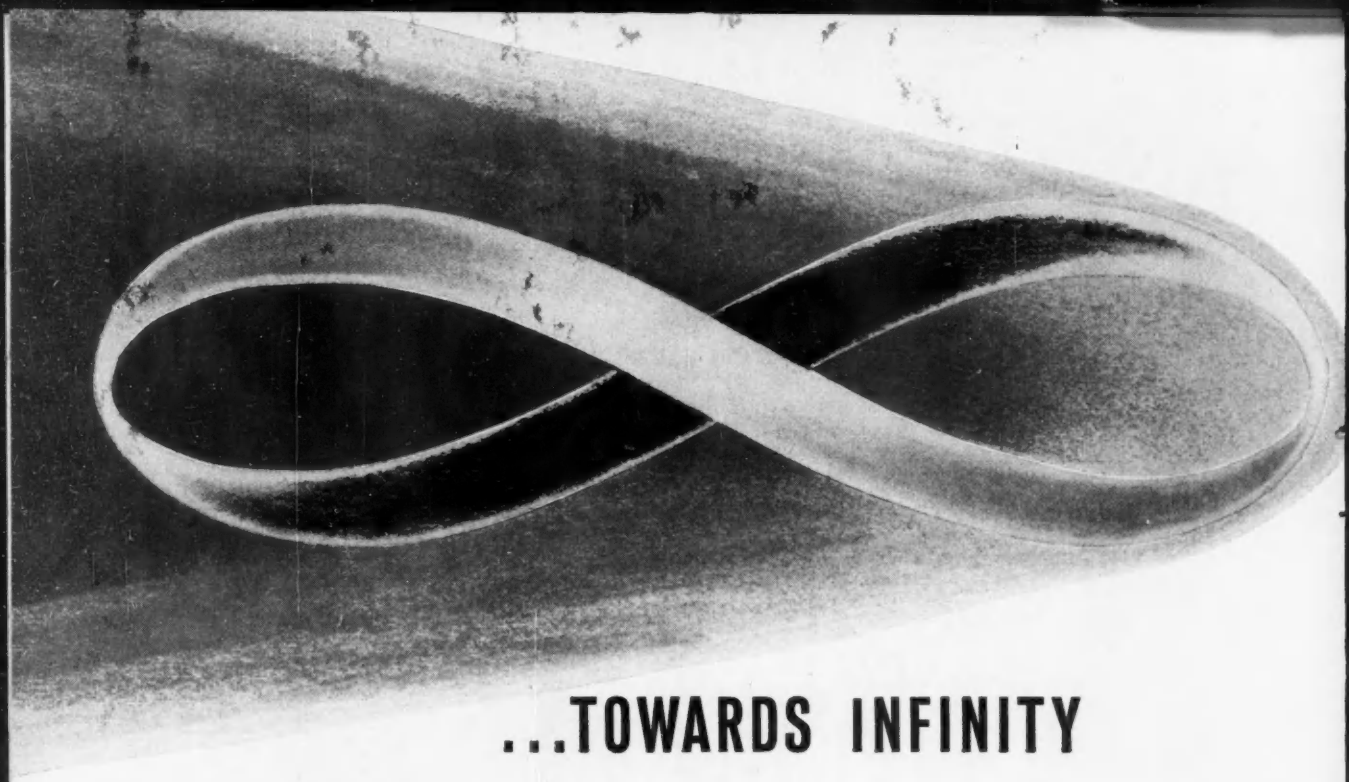
The utter simplicity of design and rugged construction assure many millions of trouble-free operations. You can choose the 8347 in either the ¼" or the ⅜" pipe size for pressures to 250 psi, and you can mount it in any position. It is available from stock for immediate delivery, as are other ASCO solenoid valves.

Write for Bulletin 8347, providing complete descriptive information on this new, reliable 4-way.

ASCO Valves ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. 506 HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • *AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL*

CIRCLE 43 ON READER SERVICE CARD



...TOWARDS INFINITY

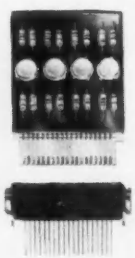
Micro MINIATURIZATION

The startling miniaturization being achieved in electronic circuits has, until recently, posed problems in interconnections. Lending themselves toward the solutions are AMPHENOL's *new and available* "Micro" family of connectors.

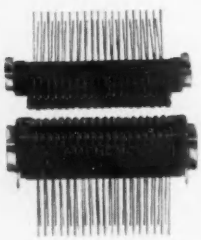
Micro-miniature flat forms, flexible printed wiring, modules, and other devices all can be reliably interconnected with AMPHENOL Micro Edge, Micro Min or Micro Mod connectors.

Connector contact centers are .075" or .050"—and smaller centers are being developed.

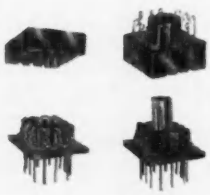
Write for complete literature



Micro Edge



Micro Min



Micro Mod

AMPHENOL CONNECTOR DIVISION

1830 S. 54TH AVE. • CHICAGO 50, ILLINOIS

Amphenol-Borg Electronics Corporation

AMPHENOL

CIRCLE 44 ON READER SERVICE CARD

it has invested in so far, either by buying securities outright or committing itself to buy other amounts when certain sales performances are met. McKinney claims, however, that ESI isn't out to build up a big electronics empire and says it has no set minimum ownership it must have in a firm before investing in it.

But the head of one small Dallas firm disputes this. The businessman says he was screened by ESI, which wanted to invest in his operation, but turned him down when he refused to give it controlling interest.

McKinney says that ESI wants enough interest "to keep us motivated". It seeks a "representative interest" in a partner firm. That means, he says, ESI wants a place on the board but not necessarily control.

• **Now partners**—Among the companies now in the ESI stable are Communications Industries, Inc. of Dallas, in which ESI owns a 34-percent interest. Others are Rawco Instruments, Inc., Ft. Worth (71 percent), Knapic Electro-Physics Inc., Palo Alto, Calif. (86 percent), R. M. Speck Electronics, Inc., Van Nuys, Calif. (47 percent, Tamar Electronics, Inc., Gardena, Calif. (75 percent), International Communications Corp., Pasadena, Calif. (40 percent), Pulse Engineering, Inc., Santa Clara, Calif. (36 percent), and General Electronic Control, Inc., Minneapolis, Minn. in which $800,000 was invested.

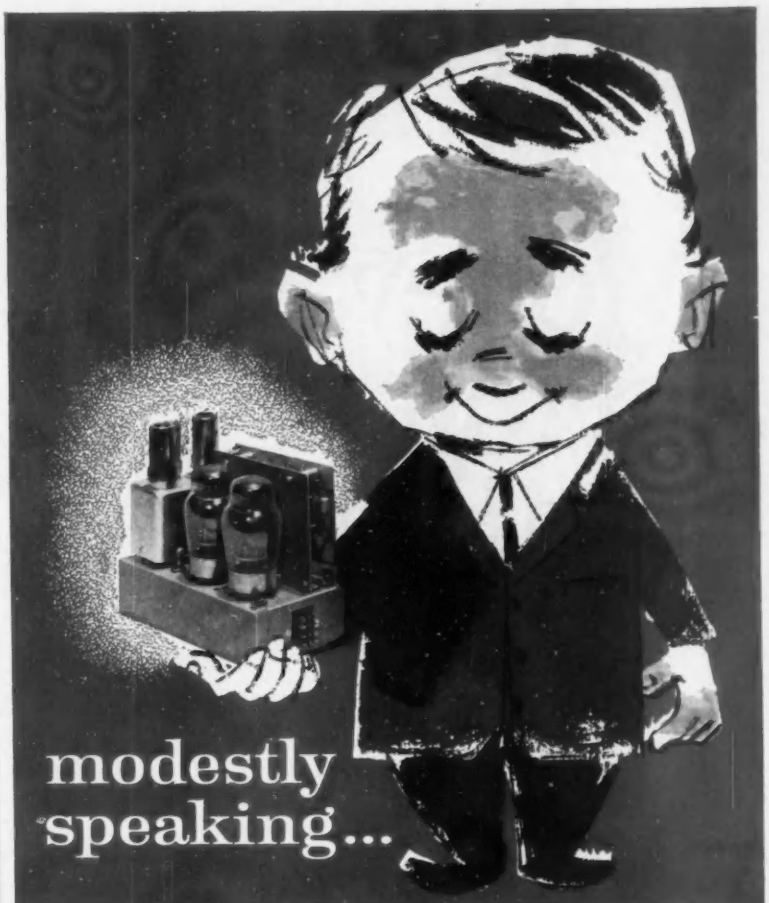
Communications Industries maintains several hundred two-way communications systems in 18 states. A CI subsidiary makes transistorized amplifiers used in these systems. CI's 1960 sales were $3.7 million, and it predicts growth to $4.5 million this year.

Rawco is a three-year old firm engaged in developing and producing electronic components and instruments, many of them for the aerospace field. Its most important product is a microminiature dc-ac contact modulator. Rawco and ESI foresee a market for it of $10-15 million. Six other products are due to be introduced in four to six months.

Knapic is the largest independent producer of crystals used in semiconductor device production. ESI says Knapic has over half of the noncaptive market for the crystals. Present $4 million yearly sales are expected to jump to $15 million after a push for broader European and Japanese sales.

It is firms like these that ESI is looking for in the future. Besides their own individual capabilities and

(*Continued on page 178*)



. . . We've really hit the jackpot with the new DIEHL Vacuum Tube Servo Amplifier. For response, linearity and power output, this new servo amplifier just can't be beat. Here are five reasons why:

- Continuous power output of 75 watts—drives DIEHL servomotors up to 25 watts 60 cycle, 15 watts 400 cycle.
- Minimum phase shift at carrier frequency.
- Plug-in input modules accept a wide range of AC and DC voltages.
- *Proven* vacuum tubes and printed circuitry assure maximum reliability.
- Separate amplifier and power supply chassis plug together.

Whatever the application, you'll find this newly perfected Vacuum Tube Servo Amplifier by DIEHL a welcome new standard of dependability and convenience. Why not get all the facts today? For additional information and/or applications assistance, contact: Diehl Manufacturing Company, Somerville, New Jersey. 4176

SPECIFICATIONS

Cat. No.	VA075-300
Output	75 Watts, Nominal
Gain	1000 volts/volt in power amplifier with max. feedback. Feedback can be reduced with potentiometer provided, with resulting increase in gain.
Input Imp.	500,000 ohms
Phase Shift	a) Less than 10° phase lag of envelope at one third carrier frequency. b) Less than 2° at carrier frequency.
Noise	100 MV., Max., Input Shorted
Power Req.	Diehl VP3-100 high voltage power supply, or equivalent.

Diehl†

†A Trademark of THE DIEHL MANUFACTURING COMPANY

DIEHL MANUFACTURING COMPANY

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Somerville, New Jersey

CIRCLE 45 ON READER SERVICE CARD

ANOTHER

Money Saving Feature

OF

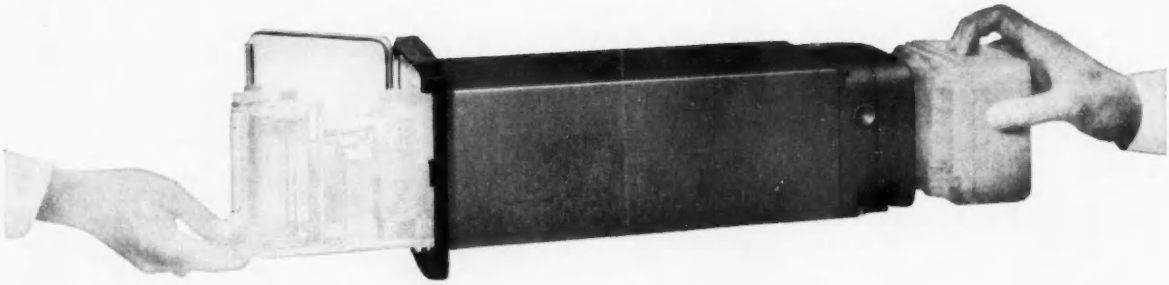
Taylor Instruments

FASTER DELIVERIES

You save up to six weeks delivery time on TRANSCOPE® Recorders and Controllers.

Here's how: We can ship you TRANSCOPE housings with manifolds within 2-4 weeks of receipt of your order. The unique plug-in features of the 90J pneumatic and 700J electronic recorders and TRANSCOPE controllers enable you to install these housings and make all necessary connections to the tagged manifolds while we complete manufacture of the instruments. You will then be ready to plug in recorder-controllers on delivery—approximately 4-6 weeks later—and be on stream immediately.

This saving in time is possible because the same plug-in features that enable us to ship the housings early permit our Production Department to build up a reserve stock of separate housings and built-in manifolds. We are geared to large quantity production that assures fulfillment of this delivery schedule.

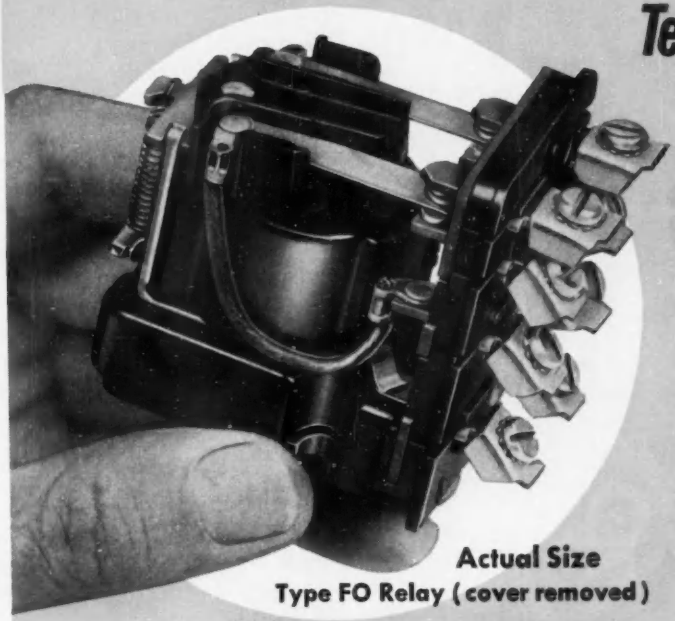


Speedier delivery is another plus value of the TRANSCOPE line, now recognized throughout industry for its many outstanding features. Ask your Taylor Field Engineer, or write for Bulletin 98286 (pneumatic) or 98335 (electronic). Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.

Taylor Instruments MEAN ACCURACY FIRST

NEW from Square D...

A SMALLER 10 AMP RELAY— WITH INDUSTRIAL FEATURES!

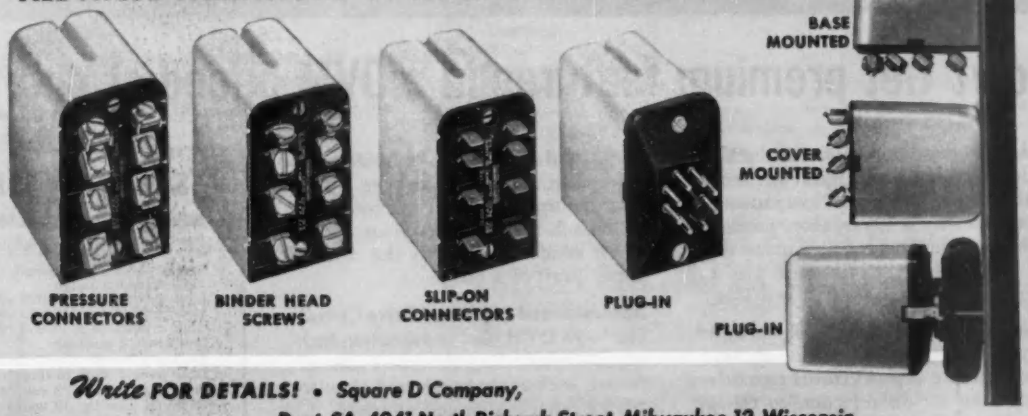


Actual Size
Type FO Relay (cover removed)

Terminal or Plug-In Wiring

- **RATINGS** easily handle solenoid loads. AC pilot duty rated 690 VA. Continuous rating 10 amperes, 125 volts AC for plug-in construction and 277 volts AC for terminal connection
- **Long Life** makes suitable for rugged machine tool applications
- **Molded coil** operates cooler and keeps out moisture for longer life
- **No solder joints** to break
- **Optional pilot light** indicates when relay is energized
- **Durable nylon dust cover** won't break, crack or support combustion

ALL THESE VARIATIONS OF WIRING AND MOUNTING



Write **FOR DETAILS!** • *Square D Company,*
Dept. SA, 4041 North Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

wherever electricity is distributed and controlled



Now! Get premium features in a DVM priced at only $940

Cubic Corporation announces the V-45 —the first low-cost digital voltmeter with premium features. Now industrial users can buy a top-quality, precision four-digit instrument at a price they can justify—only $940. Here are the premium features you get in a V-45:

Floating Input: Both sides of the input may be floated above or below ground. The floating input circuit provides more than 80 db rejection to 60-cps common-mode signals. A grounded input is also supplied.

Extended Range: A 10% extension is incorporated in each of the V-45's three ranges. Voltages up to 10.999 may be read on the 10-volt range; voltages up to 109.99 may be read on the 100-volt range; and voltages up to 1099.9 may be read on the 1000-volt range. Therefore, the operator need not constantly shift back and forth between ranges when reading close to the normal upper limit of a range.

Transistorized Logic and Drive Circuit: The V-45 DVM uses construction techniques representing the latest state-of-the-art, with all-transistorized circuitry driving reliable stepping switches.

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls. Write for literature to Dept. CT-105, Industrial Division, Cubic Corporation, San Diego 11, California.

SPECIFICATIONS

MODEL V-45 DIGITAL VOLTMETER

Input Impedance: 10 megohms at balance.
Ranges: Manually selected, 10% extended range
Low ±0.000 to ±10.999 vdc
Mid ±00.00 to ±109.99 vdc
High ±000.0 to ±1099.9 vdc
Sensitivity: 1 millivolt
Sensitivity Control: Continuously variable from 1 digit to standby lockout.
Power Input: 105-125 vac, 50-60 cps, 25 watts standby, 30 watts operating.
Dimensions: 19″ wide, 5¼″ high, 14″ deep, rack or bench mounting with dust-proof switch and bridge section.
Average Balancing Time: Less than 2 sec.

cubic CORPORATION

Norden minimizes magnetic encoder size



BuOrd SIZE 18 **GRAY-CODE MAGNETIC ENCODER SMALLEST AVAILABLE**

KETAY DEPARTMENT of Norden offers this new encoder for applications where the combination of exceptionally long wear and high speed operation in a smaller package are vital. Strengthen your system or product design with this new high standard of performance factors:

- **Smaller size.** 1.750" diameter achieved by advanced techniques of ferrite disc magnetization.
- **High-speed performance.** Offers accurate readout at speeds to 10,000 rpm.
- **Almost unlimited life . . .** since encoder is not subject to disc-to-brush contact and wear.
- **Very low-starting and running torque.**
- **Completely unambiguous output.**

TYPICAL SPECIFICATIONS

Total Count	2^s Gray Code
Rev./Full Count	1
Moment of Inertia	21 gm-cm²
Output Voltage	3 volts PTP min.
Breakaway Torque	Less than .05 oz/in
Maximum Speed (continuous interrogate)	10,000 rpm
Slew Speed	10,000 rpm
Diameter	1.750"
Weight	Under 5 oz.
Temperature Range	−65° to +125° C.
Vibration and Shock	Conforms to MilE-5272A

Send for more information on this unit and

OTHER MAGNETIC ENCODERS NOW AVAILABLE from Ketay: Gray multi-turn size 18 with count capacities of 8, 15 and 22 digits; V-scan binary size 18 with capacities of 7, 13 and 19 digits; binary coded decimal with 8-4-2-1 or 4-2-2-1 code; pure binary or cyclic units with counts of 100, 1000, 10,000. Special disc patterns and count capacities can be produced to your requirements.

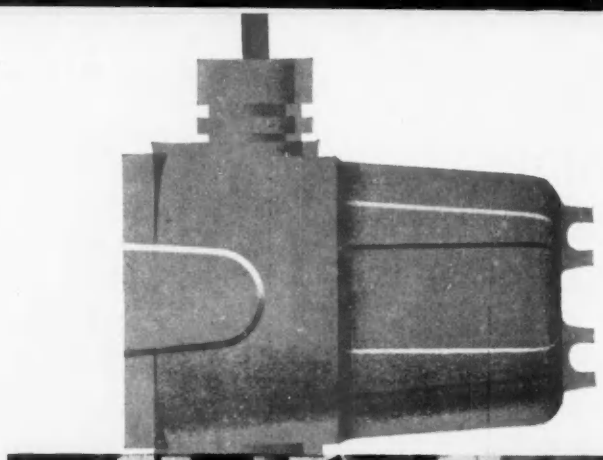
Advanced Ketay techniques are also facilitating the development of SIZE 11 Gray and V-scan encoders offering this same capacity.

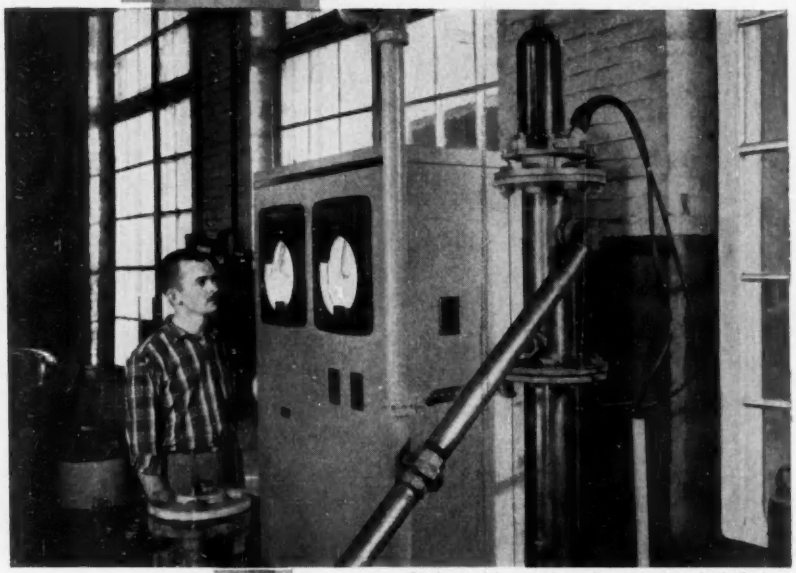
Ketay also manufactures a complete line of precision synchros, servo motors, resolvers, motor tachometers, gyros, amplifiers and encoders in a wide range of sizes and specifications to meet your specific requirements. Components are available separately or in modular packages.

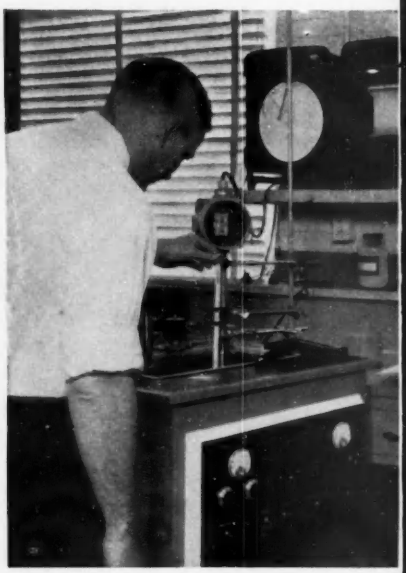
NORDEN

division of UNITED AIRCRAFT CORPORATION

COMMACK, LONG ISLAND, NEW YORK





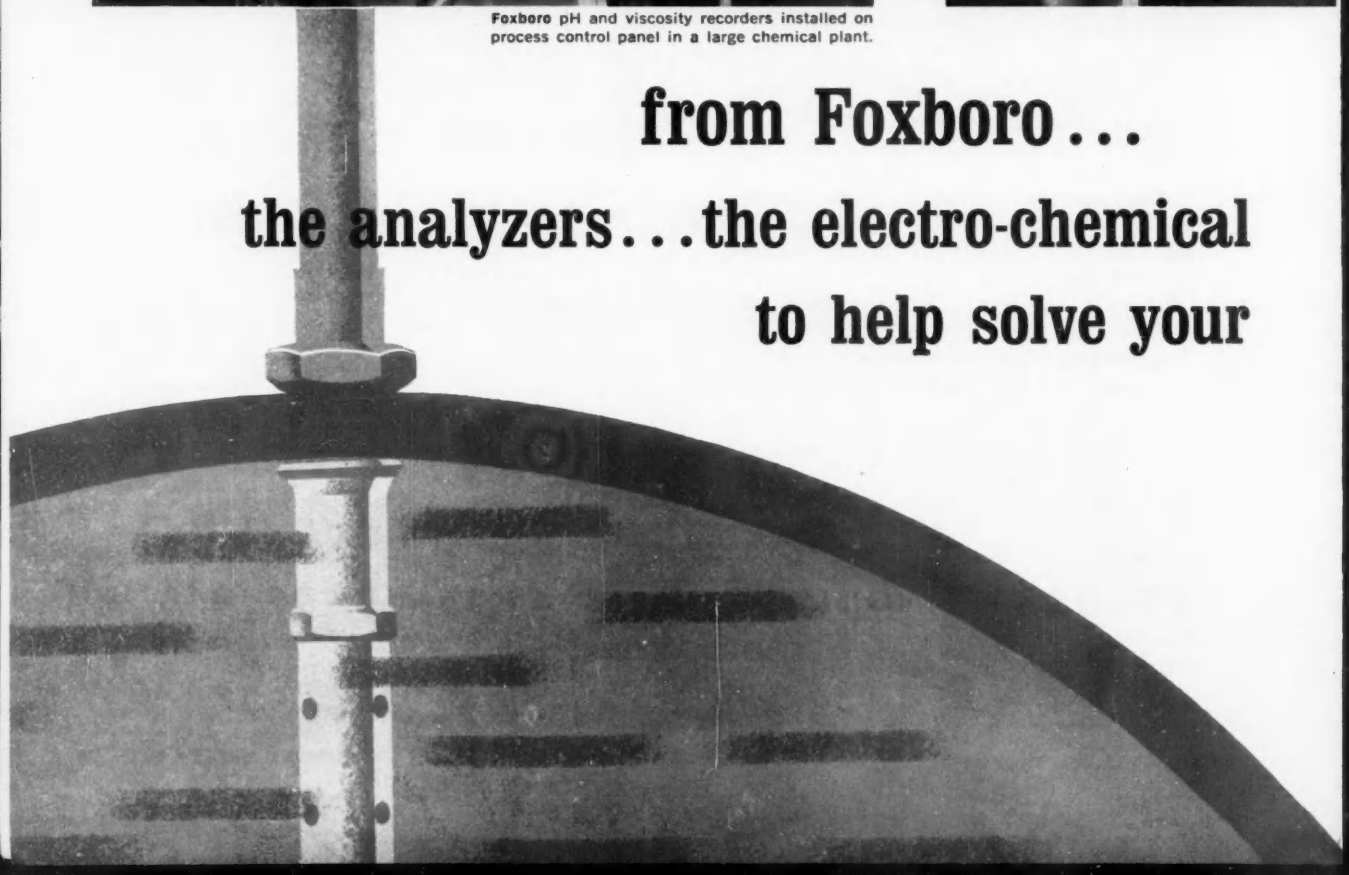


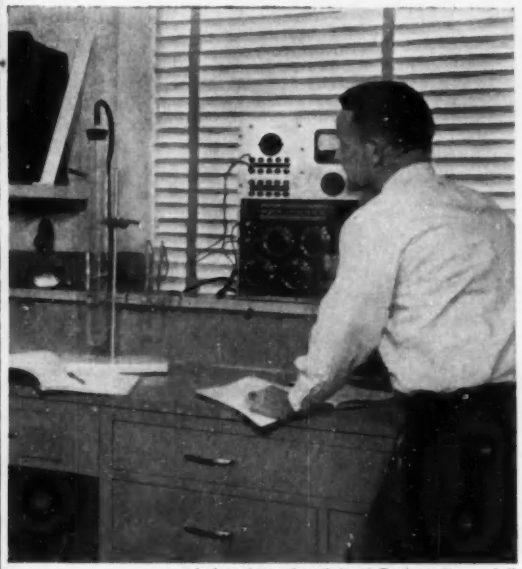
Foxboro pH and viscosity recorders installed on process control panel in a large chemical plant.

from Foxboro...

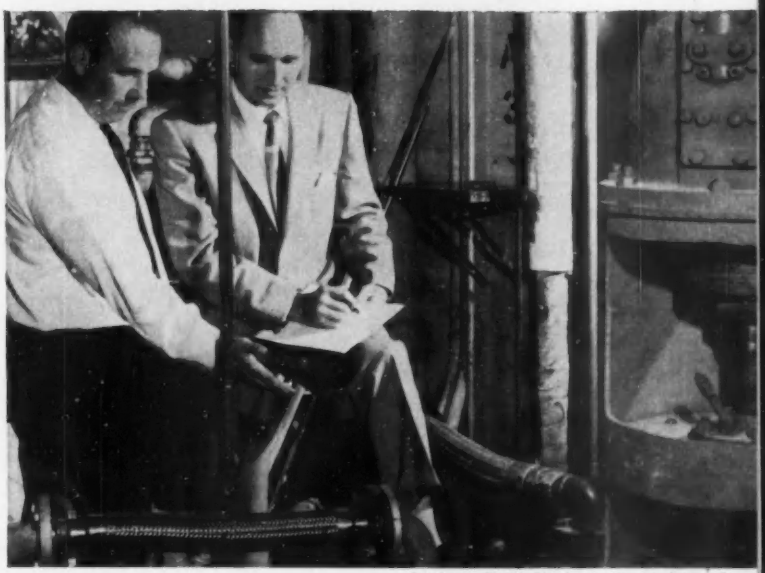
the analyzers...the electro-chemical

to help solve your





Laboratory chemists at Foxboro "sample" customer's process fluids to determine dielectric constant and conductivity.



Foxboro Field Engineer is on hand for his customer's all-important start-up day.

know-how...the engineering service process analysis problem!

pH, conductivity, amperometry, dielectric constant, oxidation-reduction potential . . . no matter what analytical measurement characterizes your process, chances are Foxboro can make it for you.

Foxboro's wide range of instrumentation covers the entire control loop. Measuring elements, transmitters, recorders, controllers, alarms — all installed as an integrated system. And all under the single responsibility of The Foxboro Company.

What about your process? Are guesswork, or slow, hand-sampling techniques hampering your operating efficiency? Why not put Foxboro to work analyzing your process stream continuously — automatically? Ask your nearby Foxboro Field Engineer for details. Or write Foxboro's Analytical Department for complete information. The Foxboro Company, 858 Neponset Avenue, Foxboro, Massachusetts.

Some of the analytical measurements Foxboro can make – pH • Oxidation-reduction potential • Dielectric constant • Amperometry • Conductivity • Viscosity • Boiling point rise.

FOXBORO

REG. U.S. PAT. OFF.

CIRCLE 51 ON READER SERVICE CARD



Kinetics 100-pole, double-throw, 15-amp switch simplifies complex switching functions

A new switch originally developed by Kinetics Corporation for space craft and missile applications is finding new uses in automatic control systems, and in measurement, computing and data handling systems. The new 100-pole, double-throw switch combines maximum reliability with extremely high density construction. It measures only 5.1" X 2.7" X 3.2" and occupies only 45 cu. in. Each contact can carry from microamps to 15 amps, continuously.

By doing away with a multiplicity of switches or relays and combining many switching functions into one compact, reliable switch, complex designs may be simplified and equipment "down" time greatly reduced. The Kinetics switch is motor-driven and once transferred, requires no power to hold it in position. Circuit contacts are of the sliding type with extremely low voltage drop. Contacts are truly captive in nature and exhibit no bounce or chatter during transfer or under rigorous vibration. The switch is hermetically sealed and can be supplied to meet customer installation requirements.

Transfer times for this design are optional down to 150 milliseconds. Available as shown with solder terminals, or with pigtailed wiring or connectors. Circuits may be timed sequentially. It is possible to mix high power circuits and low power instrumentation circuits. All circuits are transferred with one control function. A manual override can be provided if a capability for manual transfer is desired. For help with your switch requirements, write or phone Kinetics Corporation, Department KC-6, 410 S. Cedros Avenue, Solana Beach, Calif. SKyline 5-1181.

Staff Positions:

ELECTROMECHANICAL PROJECT ENGINEERS

Staff positions available in R & D on electromechanical products. Complete responsibility from original design concept through production. MS or BS degree. Write or visit our facility in Solana Beach (San Diego County) Calif. Inquiries should be directed to Warren L. Smith, Staff Employment.

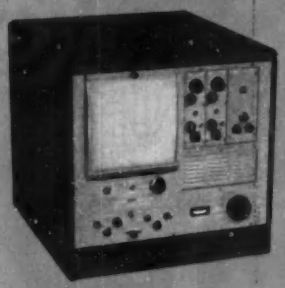
KINETICS CORPORATION

ELECTRONICS · ELECTROMECHANICS

Here's the *only* X-Y instrument today that gives you extremely *fast response time — direct, large area recordings — 1% linearity:* the SANBORN MODEL 670A X-Y RECORDER. The capabilities of the 670A make it particularly valuable in such applications as rapid recording of diode and transistor characteristics . . . hysteresis curves for control systems, gyros, servo valves, magnetic coils; velocity or acceleration vs. vibration of mechanical elements.

Inputs to each axis are through interchangeable "850" series preamplifiers, and can range from microvolts to volts. With Model 850-1500A Low Level preamplifiers, 62.5 uv gives a 1" chart deflection; with Model 850-1300B DC Coupling preamps, 31.25 mv gives 1" chart deflection. To record one variable against time on the X-axis, the Model 670-800 Time Base Generator is also available. A plug-in MOPA is available to supply fixed frequency excitation to preamplifiers.

Recordings are made on 8" x 8" daylight-loading, ultraviolet-sensitive charts by an optical (light beam) recording system. The trace may be monitored on phosphorescent screen before recording, beam intensity is adjustable for maximum sharpness, and X and Y axes may be recorded directly on the chart. Brief post exposure in room light develops the record.



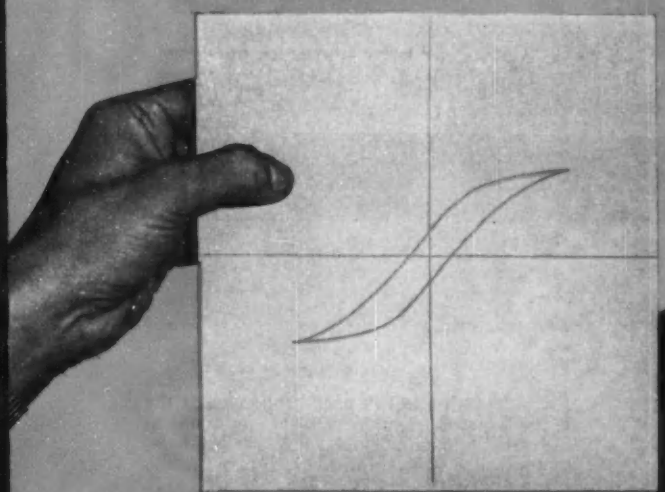
SPECIFICATIONS

Input: single-ended or push-pull
Input Impedance: 5 megohms from each high input terminal to ground with 850-1300B preamplifier
Frequency Response: to 130 cps within 3 db at 8" peak-to-peak deflection
Sweep Rates with Time Base Generator: from 0.01 to 2 seconds
Output Drift: 0.04 inch/hour with 850-1300B
Packaging: Optional cabinet 21¼" x 20" x 20" high, or can be rack mounted in 15¾" of panel space
Power Requirements: 450 watts, 115 volts, 60 cycles AC

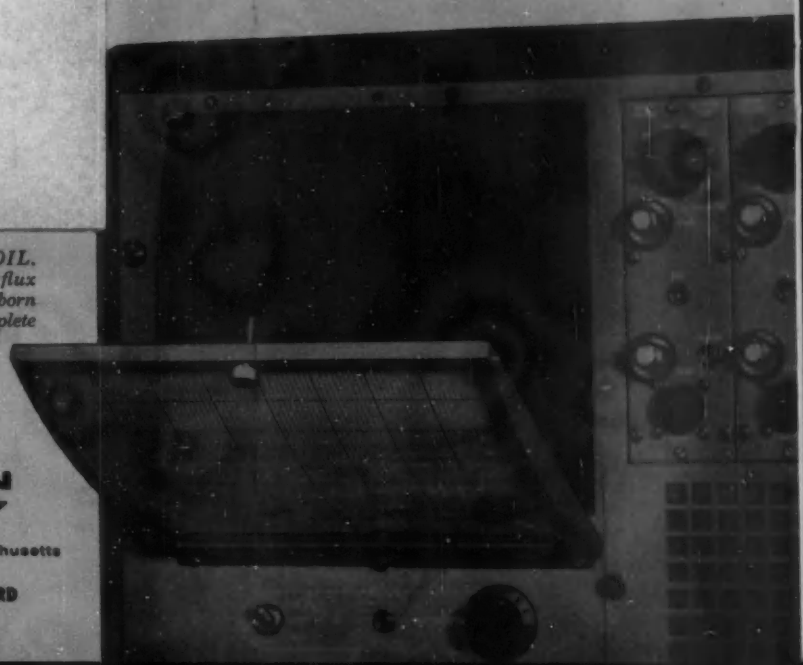
Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670A X-Y Recorder, or write the Industrial Division in Waltham, Massachusetts.

Record 100th-of-a-second X-Y variables directly

- *at 2500"/sec. writing speeds*
- *on 8" x 8" charts*
- *with 1% linearity*
- *from microvolts to volts*



HYSTERESIS IN MAGNETIC COIL. This plot of magnetomotive force vs. flux density was recorded on the Sanborn Model 670A X-Y Recorder. The complete trace was made in 1/60th sec.

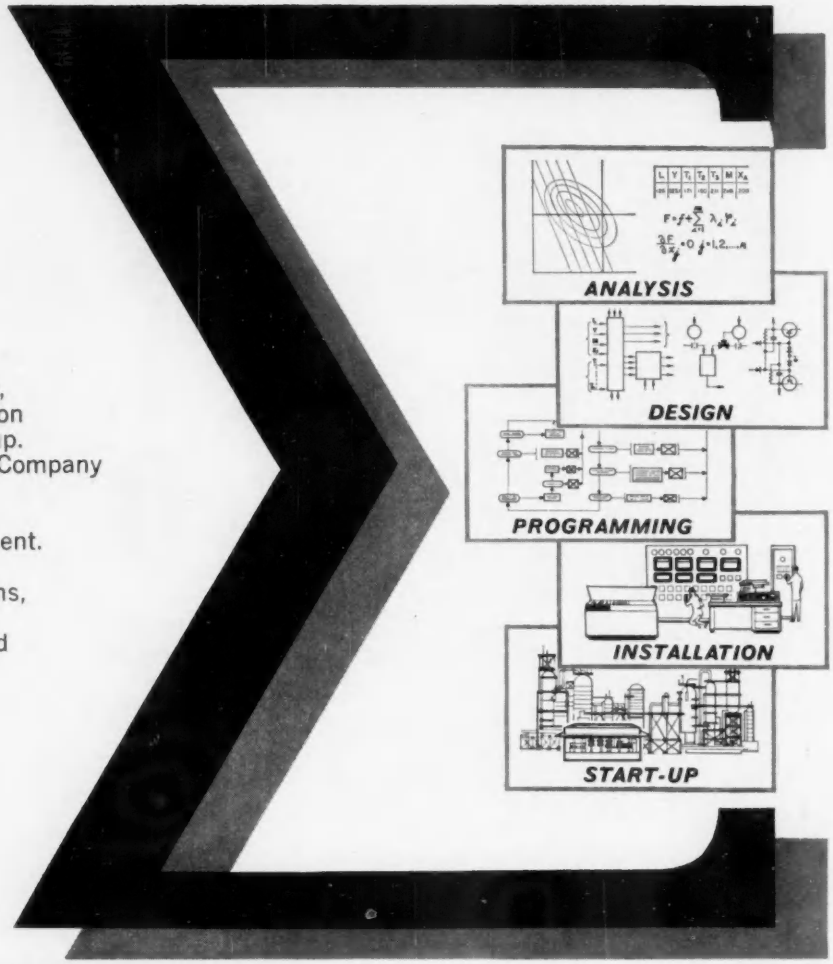


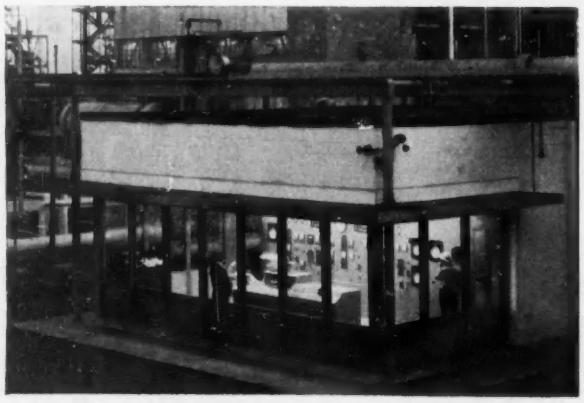
SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

CIRCLE 53 ON READER SERVICE CARD

TOTAL ABILITY IN COMPUTER CONTROL

TOTAL ability in computer control means proven capability in process analysis, system design, control programming, equipment installation and system start-up. TRW Computers Company has this proven capability plus field-proved equipment. In process control and related applications, RW-300 Digital Control Computers have operated more than 200,000 hours with reliability better than 99 percent.





Pictured at the left is a control room of the B. F. Goodrich Chemical Company plant at Calvert City, Kentucky. An RW-300 has been in control of vinyl chloride production at this plant since early in 1960.

This application and other applications in the petroleum, chemical, and power industries are described in a brochure summarizing the experience of TRW Computers Company. To obtain a copy of the brochure, write to any of the offices listed below.

TRW Computers Company

a division of *Thompson Ramo Wooldridge Inc.*

8433 FALLBROOK AVENUE · CANOGA PARK, CALIFORNIA

200 East 42nd Street, New York 17 · New York
1510 Esperson Building, Houston · Texas
200 South Michigan Ave., Chicago · Illinois
220 North Canon Drive, Beverly Hills · California

NOW FAIRCHILD DIFFUSED SILICON INDUSTRIAL TRANSISTORS

NEW LOW PRICED '2N' TYPES FOR COMMERCIAL/ INDUSTRIAL APPLICATIONS

- Commercial computers
- Business machines
- Industrial controls
- Industrial power supplies
- Test instruments
- Monitors and alarms
- Communications equipment
- Medical apparatus

THE BEST BASIC TYPES, double-diffused silicon with low saturation resistance and a reserve of speed, power handling and current range that permit the widest latitude in circuit design.

AT COMPETITIVE PRICES, now comparable or lower than industrial germanium or silicon transistor types of more limited performance.

WITH ASSURED AVAILABILITY through regular Fairchild distributors. The Fairchild name and the 2N numbers protect the circuit designs you base on these specifications.

ELECTRICAL CHARACTERISTICS
(25° C except as noted)

TYPES	DESCRIPTION	JEDEC OUTLINE	f_T TYPICAL	P_C@25°C CASE TEMP.	h_{FE} MIN.	h_{FE} MAX.	V_{CER}	V_{CBO}	$V_{BE(Sat)}$ MAX.	$V_{CE(Sat)}$ MAX.	I_{CBO}@25°C MAX.
2N1985 2N1984 2N1983	Small signal types for AC and DC amplifiers	TO-5	50 mc	2 watts	15* 35* 70*	45* 100* 210*	40	50	—	—	5 μA
2N1987 2N1986	Switching types	TO-5	50 mc	2 watts	20 60	80 240	40	50	0.9	0.6	5 μA
2N1989 2N1988	High voltage types particularly suited to video amplifiers and RF oscillators	TO-5	50 mc	2 watts	20 35	60 120	60	100	1.0	2.0	5 μA
2N1991	PNP complement to the small signal and switching types	TO-5	50 mc	2 watts	15	60	25	30	—1.5	—1.5	5 μA
2N1990	Neon tube and Nixie® driver type	TO-5	—	2 watts	20	—	60	100	1.0	0.5	—

Nixie Registered Burroughs Corporation.

* For the small signal types, this specification is h_{fe} at 1 k_c instead of h_{FE} at DC.

Write for full specifications

FAIRCHILD SEMICONDUCTOR CORPORATION

545 WHISMAN ROAD, MOUNTAIN VIEW, CALIF.-YORKSHIRE 8-8161-TWX: MN VW CAL 853
A wholly owned subsidiary of Fairchild Camera and Instrument Corporation

AE



TO THE ENGINEER

who needs the magic of mercury

If you're stymied by switching problems in data processing, automatic control or high-speed keying, then consider the unusual attributes of AE's Series V51 mercury-wetted contact relay.

This fleet switcher can be driven at speeds up to 100 operations per second, completely free from contact bounce. It requires no maintenance within its life of over a billion transfers. The contacts can switch dry circuits or handle loads up to 250 volt-amperes. Operate and release time is approximately 3 milliseconds.

Contact and armature assemblies of the V51 are hermetically sealed in a glass capsule with a high-pressure hydrogen atmosphere. Mercury wetting continuously renews the contacts, eliminates wear, erosion, welding and sticking. Operating sensitivity is 250 milliwatts, minimum.

AE engineers will be glad to aid in applying the V51 to your designs. Ask for Circular 1988 covering full specs on the V51. Write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AE CAN DO

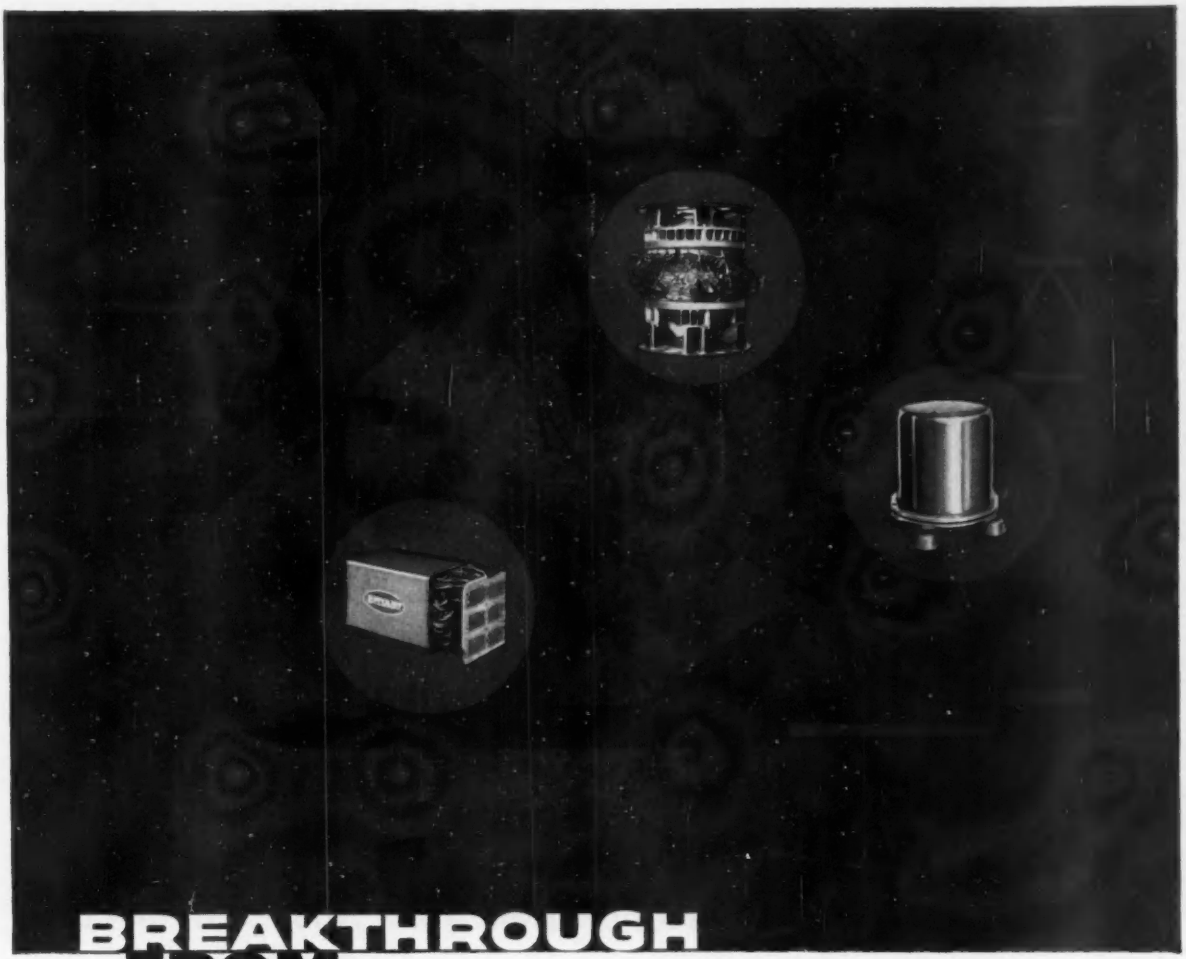


AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM



BREAKTHROUGH FROM BRYANT

A FULL FAMILY OF AIRBORNE MAGNETIC DRUMS

To fill the exacting requirements of airborne operations, Bryant announces a complete family of magnetic storage drums for general and special purpose applications in aircraft, missile, and satellite systems. Incorporating rugged, lightweight, shock-resistant construction, Bryant airborne drums qualify to military specifications by independent laboratory tests. Features include:

- Capacities to one million bits.
- Minimum weight and package size.
- Bit rates to one megacycle.
- Speeds to 18,000 RPM.
- Qualified to MIL-E-5400.

For details, contact your nearest Bryant representative, or call direct.

BRYANT

COMPUTER PRODUCTS

Disc File and Magnetic Drum Memories for Every Storage Application

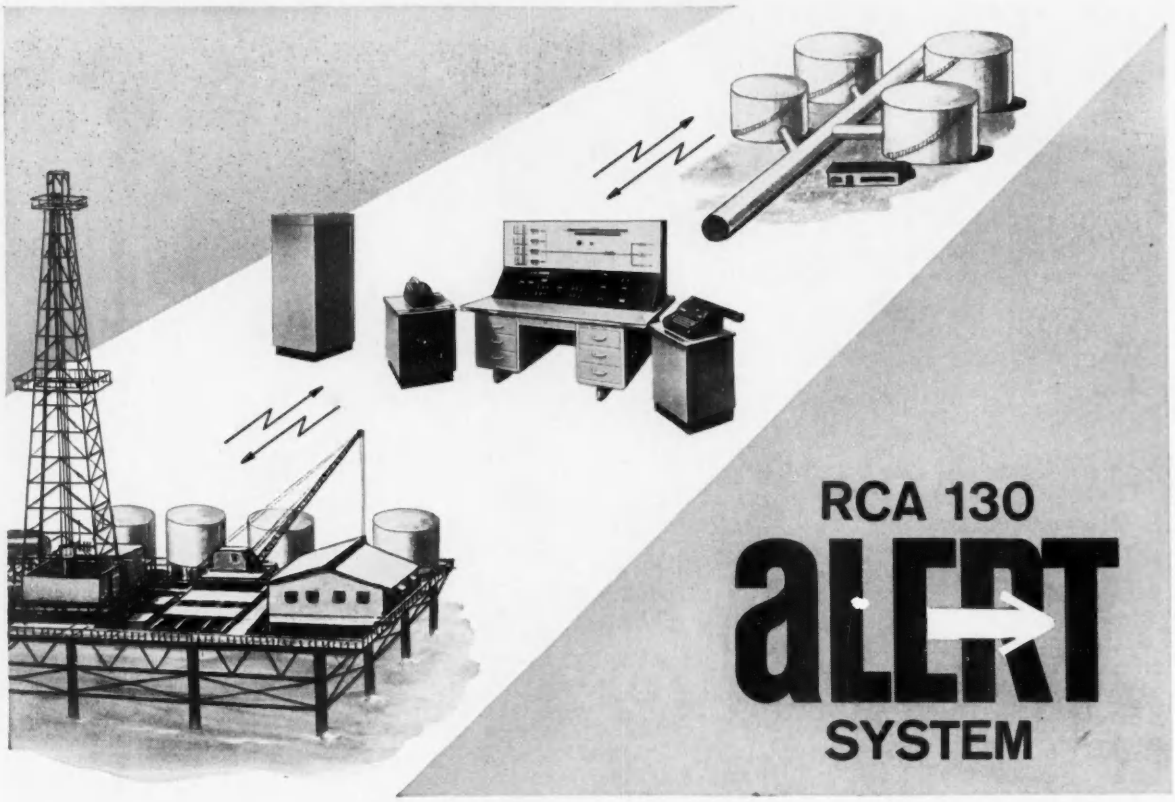
852 Ladd Road • Walled Lake, Michigan • MArket 4-4571

A DIVISION OF EX-CELL-O CORPORATION

61-37CP

JUNE 1961

CIRCLE 57 ON READER SERVICE CARD 57



The Supervisory Control System that rules out error

The RCA 130 ALERT System—*A*utomatic *L*ogging, *E*lectronic *R*eporting and *T*elemetering—tells you instantly and precisely what's happening in gas and oil production and pipeline remote operations . . . gives you accuracy and reliability that provides the same confidence you would have if you were at the remote location yourself.

Through its built-in accuracy features, ALERT offers security that makes it virtually impossible for false information or control to be initiated.

For further information on how ALERT can solve your Data Logging and Supervisory Control problems, write RADIO CORPORATION OF AMERICA, Industrial Computer Systems Department, Electronic Data Processing Division, 21 Strathmore Road, Natick, Massachusetts.

ALERT ends your system and application problems too—

- *COMPLETE FLEXIBILITY of the ALERT System permits operation over virtually all communications media, and incorporation of already existing telemetering, control and display equipment.*
- *RUGGED DESIGN assures better than 99 per cent uptime, whether ALERT is operating on a frigid mountain top, a boiling desert or in humid off-shore conditions.*
- *THREE-WAY EXPANSIBILITY of ALERT —expansibility in speed, in number of functions per station, and number of stations per system . . . allows you to add new abilities in the field without interrupting control . . . protects your investment with growth possibilities that look far into your future.*

RCA ®

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

A NEW ADDITION TO THE SONAC *LINE*

POSITIVE ULTRASONIC LEVEL CONTROL



The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.



FIG. 1—LIQUID LEVEL (One Sensor)



FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005″ and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

Canadian Representative:

KNOWLES & FOSTER (North America) Ltd.

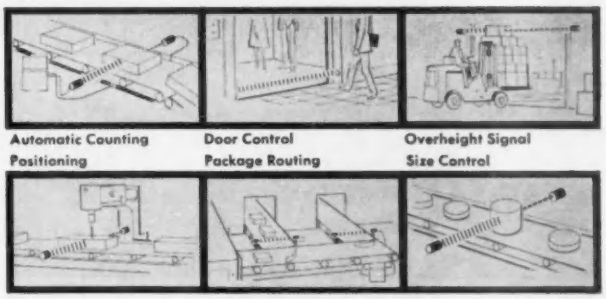
708 Terminal Bldg., Toronto 1, Ontario, Canada

A

SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5″ x 5″ x 5″ and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

Here's how SONAC can be used for sensing and switching applications other than level control.



Automatic Counting Positioning | Door Control Package Routing | Overheight Signal Size Control

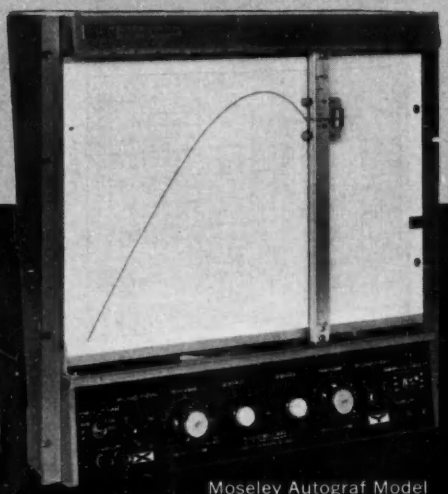
There are dozens of applications for SONAC *single and double sensor units. Let it go to work for you now, write:*

DELAVAN Manufacturing Company

WEST DES MOINES • IOWA

CIRCLE 59 ON READER SERVICE CARD

Today's most versatile 11"x17" XY-(T)* Recorder



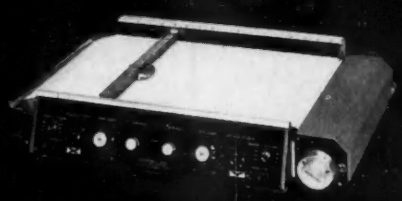
Moseley Autograf Model 2DR Recorder, today's most compact 11"x17" rack-mount instrument!

COMPACT RACK MOUNT

*Built-in time base

Moseley Autograf Model 2DR Recorder mounts flush with rack, takes only 17½" of rack space, is only 5⅛" deep behind control panel, ideal for systems use.

Accepts ac or dc input on each axis, includes calibrated X-axis time base, scale factor vernier, 16 dc ranges, 8 ac ranges, 7 calibrated sweeps on X-axis time base. DC accuracy greater than 0.2% full scale. $2450.



The Moseley 2D, a benchtop recorder, features the same size and flexibility advantages as the 2DR. This is today's most versatile bench instrument, has all the electronic features of the 2DR and is readily convertible to roll chart use. $2350 (roll chart accessory, $450 additional).

Write today for full details

Now available! Models 2D-2, $1,950.00, and 2DR-2, $1,975.00, identical to the above instruments, except without ac converter.

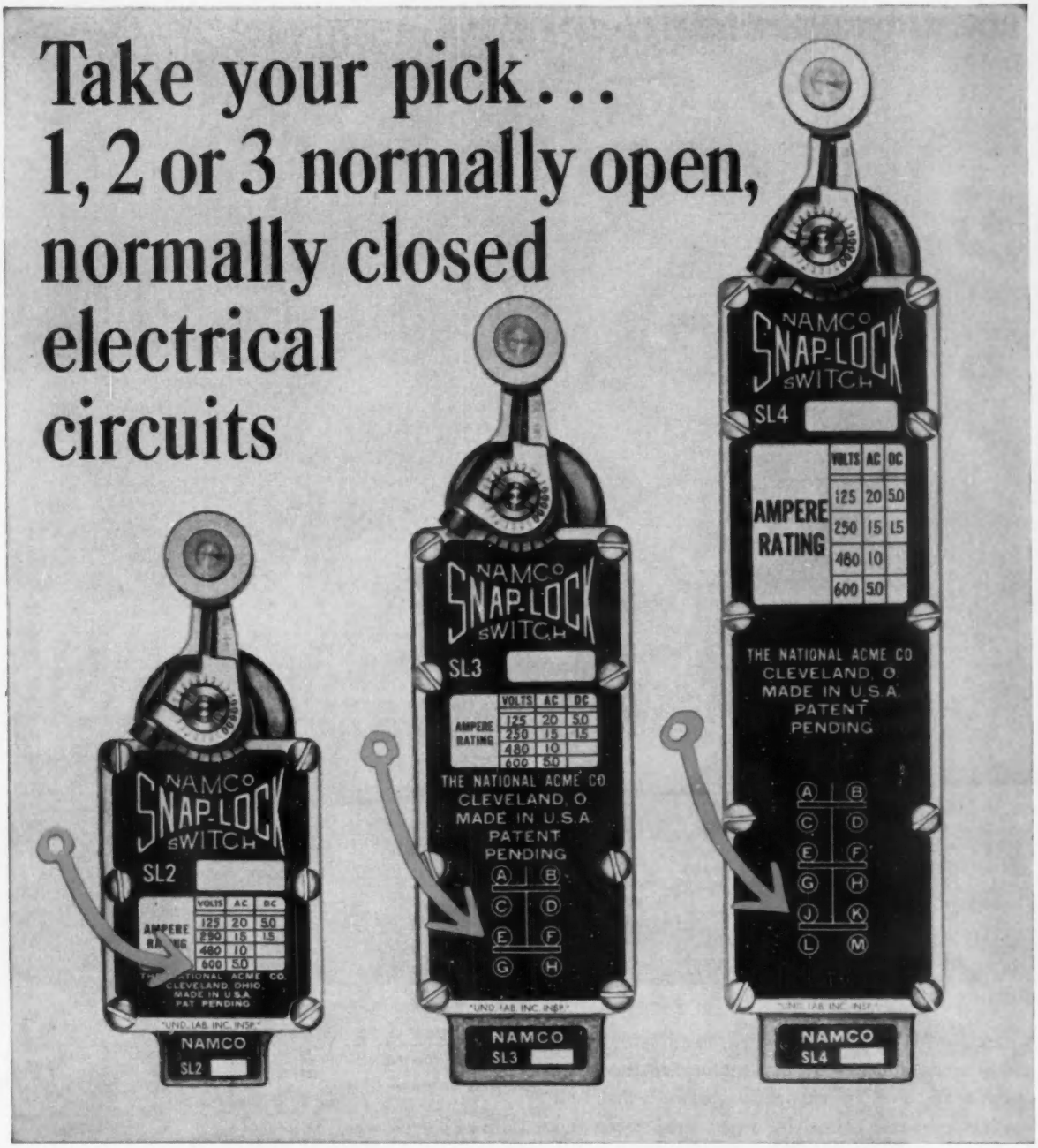
AUTOGRAF *recorders*

F. L. MOSELEY CO.

Dept. H-6, N. Fair Oaks Avenue, Pasadena, California
Murray 1-0208 TWX PASA CAL 7687, Cable Mocopas

Field representatives in all principal areas • Data subject to change without notice • Prices f.o.b. Pasadena • Pioneer and leader in X-Y and and Strip-Chart Recorders

Take your pick... 1, 2 or 3 normally open, normally closed electrical circuits



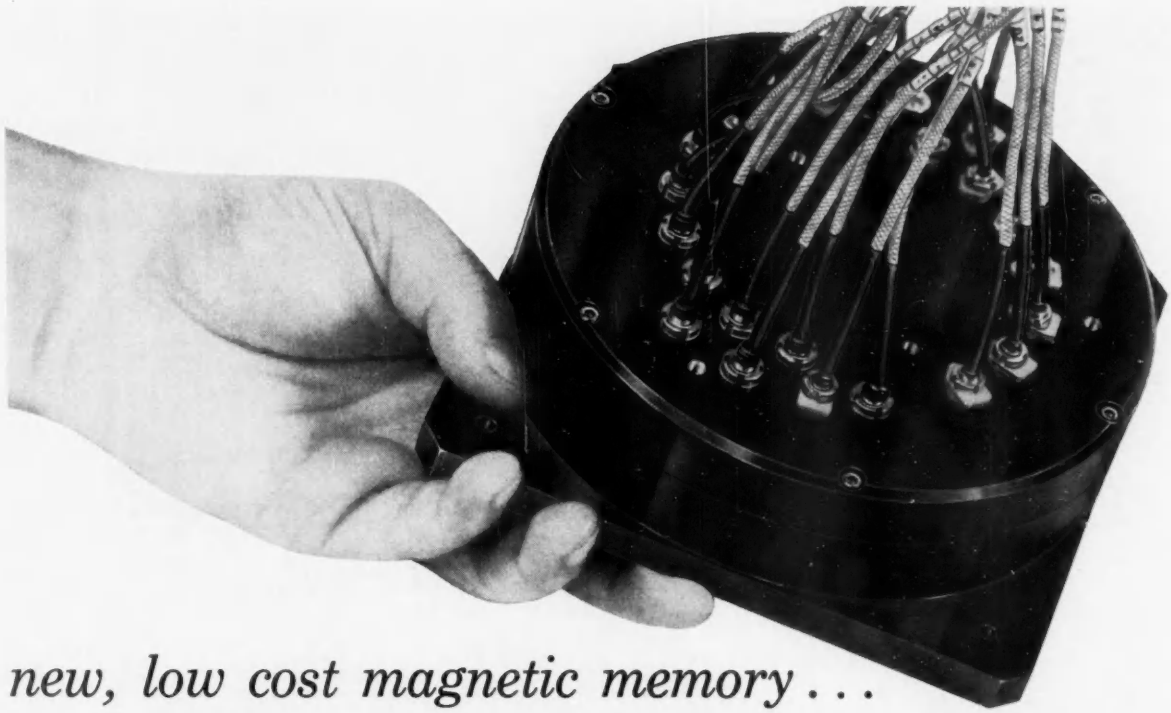
What does your limit switching application call for . . . one, two or three normally open, normally closed electrical circuits? Whatever it is, one of these National Acme SL "Machine Life" Limit Switches . . . the SL2, the SL3 or the SL4 . . . will meet your precise requirement. And, every SL offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (10½ lbs. at 1½" radius). Also available . . . the SLS 2, 3 or 4 featuring "hi-shock" sliding contacts: particularly suitable for drop forge, punch press and other heavy equipment application. Call, write or wire for complete information.

National Acme

THE NATIONAL ACME COMPANY
165 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

CIRCLE 61 ON READER SERVICE CARD 61



new, low cost magnetic memory . . .
25,000 bit capacity . . . 5¾" x 5¾" x 5" . . . 5 pounds



The BD-10 Series is the latest addition to LFE's expanding line of Bernoulli Disk Memory Systems. It has been designed to fill the need for a low capacity, low cost storage device. It is available in single units for laboratory use, or in high volume production for use with all digital computers utilizing magnetic storage media.

A flexible Mylar magnetic disk, headplate, read/write heads and a precision motor are the basic components. Positive separation between disk and headplate is maintained by centrifugal force and the Bernoulli principle of fluid motion. The unit's low mass plus a cushion of air make damage to disk or read/write heads virtually impossible . . . even under the most severe environmental conditions. Write Marketing Manager, Computer Products Division, for prices and complete data.

SPECIFICATIONS BD-10 SERIES

Storage Capacity (max.) Bits	25,000
Disk Diameter (max.) Inches	4
Bits per Track (max.) @ 1½" radius	2,300
Bit Rate — kc	10-500
Track Layout As Required	
Typical:	
Total Tracks:	12
Data Storage Tracks	*
Spare Tracks	*
Clock and Timing Tracks	*
Register Tracks	*
Number of Registers	*
Register Length — Bits (minimum @ 2,300 B/T)	32
Register Adjustment — Bits	±3
Disk Speed — RPM Induction or Synchronous Motors Available	6,000-12,000
Power Source — cps	400
Magnetic Heads (Compatible with solid state circuits)	
Standard Heads	
Inductance (Per Leg. — C.T. Coil) uh	40, 55, 90
Write Current (O/P Manchester) ma (nominal)	125
Read Out (Min. P/P Full Coil) — mv (nominal)	20
Size — Inches	5¾ x 5¾ x 5
Weight — Pounds	5

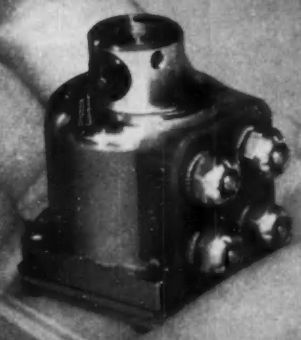
*Wide variety of specifications can be provided to meet customer's requirements.

LFE
COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.
1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

CIRCLE 63 ON READER SERVICE CARD →

Watch Weston for new concepts...



This miniature, electro hot-gas servo valve developed by Weston for the U.S. Army's "Mauler" Missile weighs only .18 pound.

Now Weston
GAS SERVOS
and **SYSTEMS**
offer new standards
of performance!

From this tiny gas actuated servo, to complete hot or cold gas-servo systems, Weston's pioneering of this advanced control concept has produced a practical design – proved reliable – and offering new standards of performance. ■ Eliminating the conventional "soft" response usually associated with gas actuators, this new design provides the fast forward response and positive reverse stiffness of a hydraulic system – yet operates way beyond the environmental limits of hydraulics. It can be stored indefinitely, has fewer components for greater inherent reliability, and up to 50% less weight than a hydraulic system. ■ A general bulletin is available on this new Weston design, and a specific proposal or a test demonstration can be arranged on request.



Development and test firing of Weston Gas Servo Systems are conducted in this special laboratory.

weston

HYDRAULICS LIMITED

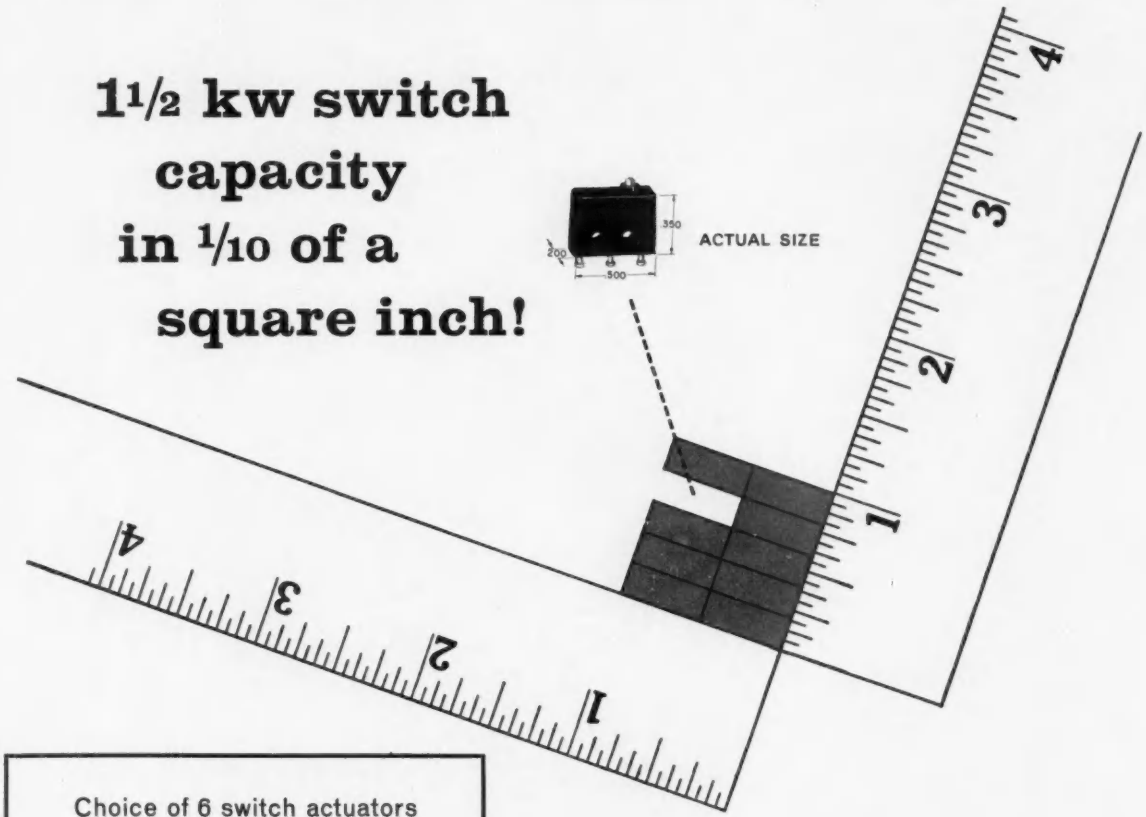
A SUBSIDIARY OF BORG-WARNER CORPORATION

WESTON HYDRAULICS B-W BORG-WARNER

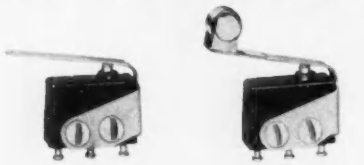
7500 Tyrone Ave., Van Nuys, Calif. • Telephone TRiangle 3-4340

Mauler is being developed by Convair/Pomona, Convair Division of General Dynamics, for the Army Rocket and Guided Missile Agency, an element of the Army Ordnance Missile Command.

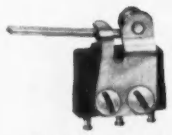
1½ kw switch capacity in 1/10 of a square inch!

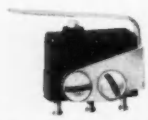


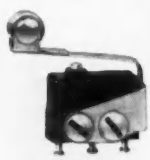
Choice of 6 switch actuators

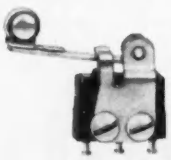

Leaf actuator

Roller leaf actuator


Pivoted lever actuator


Reverse leaf actuator


Reverse roller leaf actuator


Pivoted roller lever actuator

THE MICRO SWITCH "1SX1" is the smallest single-pole double-throw snap-action switch made. It weighs only 1 gram. Yet, despite its tiny size, it performs millions of operations, in temperatures ranging from −65° F. to +250° F. And it handles precision switching jobs at capacities up to 1½ kw.

The case, cover and plunger are made of high-strength plastic. Contacts are fine silver. The unique, snap-action spring is beryllium copper. The case has two mounting holes that accept No. 2 screws. One hole is slightly elongated to facilitate mounting. "1SX1" is designed to conform to MS24547-1.

MICRO SWITCH manufactures a complete line of small basic switches. See the Yellow Pages for your nearby MICRO SWITCH Branch Office. Or write for Catalog 63.

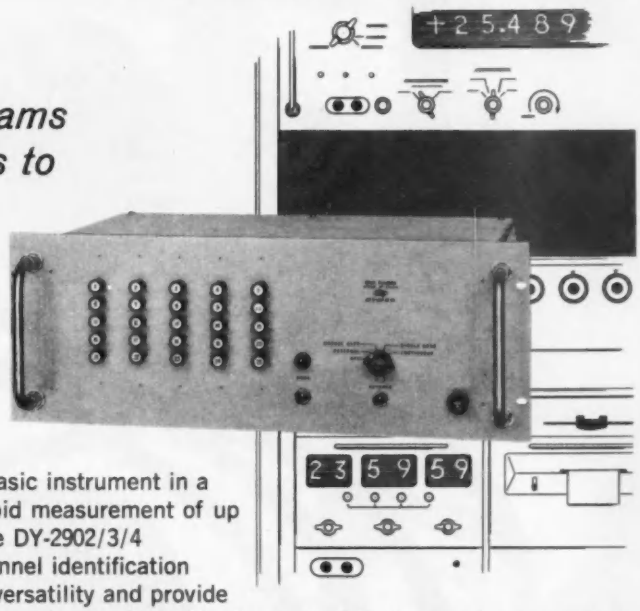
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

HONEYWELL INTERNATIONAL
Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

EFFICIENT AUTOMATIC MULTI-POINT MEASUREMENT

New Input Scanner programs up to 100 data points to one measuring device



With off-the-shelf Dymec instrumentation it's simple to measure pressure, flow, temperature, velocity, volume—any parameter that can be converted to or related to a voltage, frequency, time interval or period, resistance or current.

Using the DY-2901 Input Scanner as the basic instrument in a system, for example, you can program rapid measurement of up to 25 points—or up to 100 inputs with the DY-2902/3/4 slave scanners. Built-in programming, channel identification and latch-lock input connectors increase versatility and provide money-saving utility. Channels to be measured are selected by front-panel buttons and programmed by an internal pin board which lets you select function and range of the measuring equipment.

With the DY-2901, you can make more effective use of other Dymec instruments such as the DY-2401 Integrating Digital Voltmeter, the DY-2410 Multi-Converter, and the DY-2540 Coupler. Application Note 15 describes complete Dymec Systems capabilities.

Here are some of the inputs you can measure with these systems:

- dc voltage, from a few mv to 1,000 v
- ac voltage, from a fraction of a volt to 750 v rms, 20 cps to 100 KC or more
- frequency, dc to 10 MC or more
- time interval or period, from less than 1 nanosecond to 100 days
- resistance, fractions of an ohm to 100 megohms or more
- current, from 10^{-9} amps to 10 amps or more

And here are some of the features your Dymec system can provide:

- Scaling: Multiplying factors can be pre-set to provide digital readings in desired measuring units (psi, gpm, rpm, etc.)
- Ranging: Measuring equipment can be automatically programmed to desired range for each channel
- Normalizing: Separate multiplying factor can be supplied for each channel to relate all measurements to a par value
- Scale Expansion: Zero offset provides high measurement resolution on each range
- Sequence: Individual channels can be omitted from any measurement cycle

Call your Dymec/Hewlett-Packard representative today or call direct for specifications on the DY-2901 Input Scanner ($1,950), DY-2401 Digital Voltmeter ($3,750), DY-2410 Multi-Converter ($1,975), DY-2540 Coupler (typically $1,200 to $2,400), or other Dymec instruments for versatile systems application.

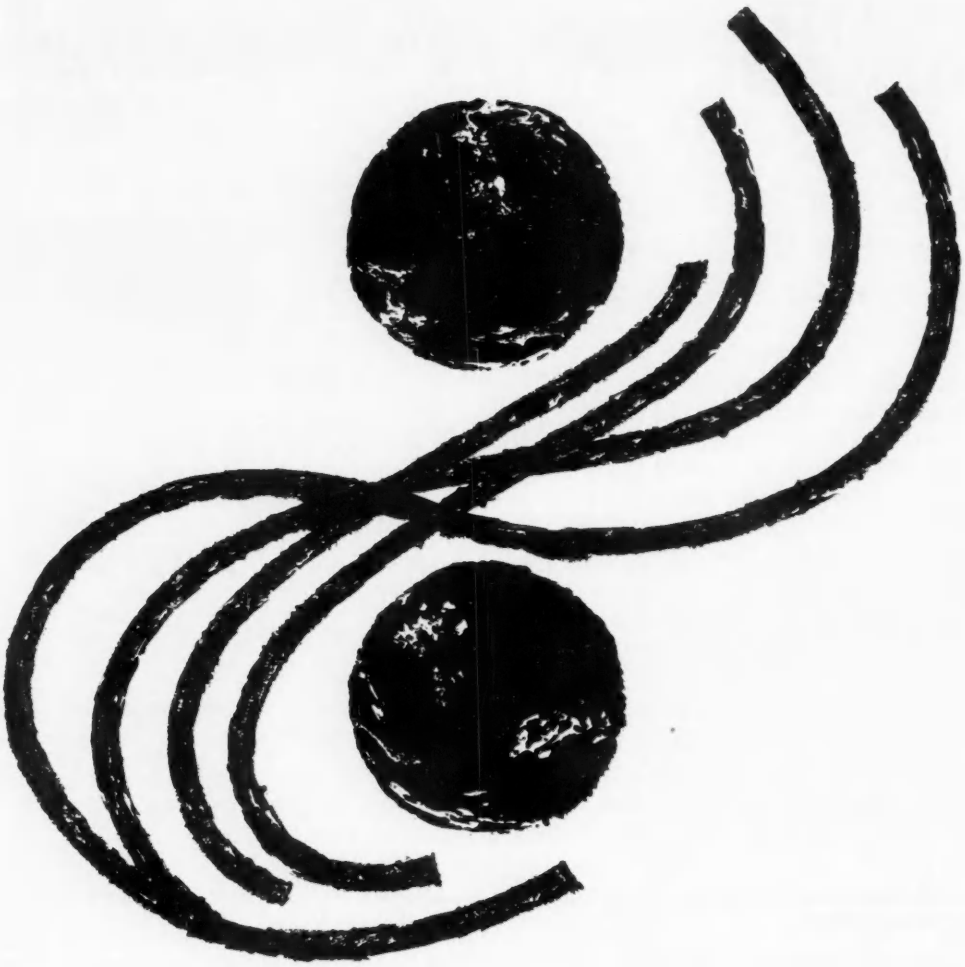
DYMEC

A Division of Hewlett-Packard Company

dy

Dept. C-6, 395 Page Mill Road, Palo Alto, California • DAvenport 6-1755 (Area Code 415)

TWX-117-U



Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

With interplanetary voyages fast becoming a reality, complete information regarding the velocity requirements for travel between planets is of vital importance. With these data available, it is possible to analyze propulsion requirements, plan ultimate system configurations, and conduct feasibility studies for any particular mission.

Lockheed Missiles and Space Division scientists have actually evolved a rapid-calculation method, utilizing a high-speed computer. This has produced literally thousands of orbits, velocity requirements, and elapsed time, for design studies of trips to and from both Mars and Venus—every tenth day from now until January, 1970.

More simple to analyze are many factors which make Lockheed Missiles and Space Division a wonderful place to live and work. Located in Sunnyvale and Palo Alto, California, on the beautiful San Francisco Peninsula, Lockheed is Systems Manager for such programs as the DISCOVERER and MIDAS satellites and the POLARIS FBM. These, together with research and development projects in all disciplines, make possible a wide diversity of positions for creative engineers and scientists in their chosen fields.

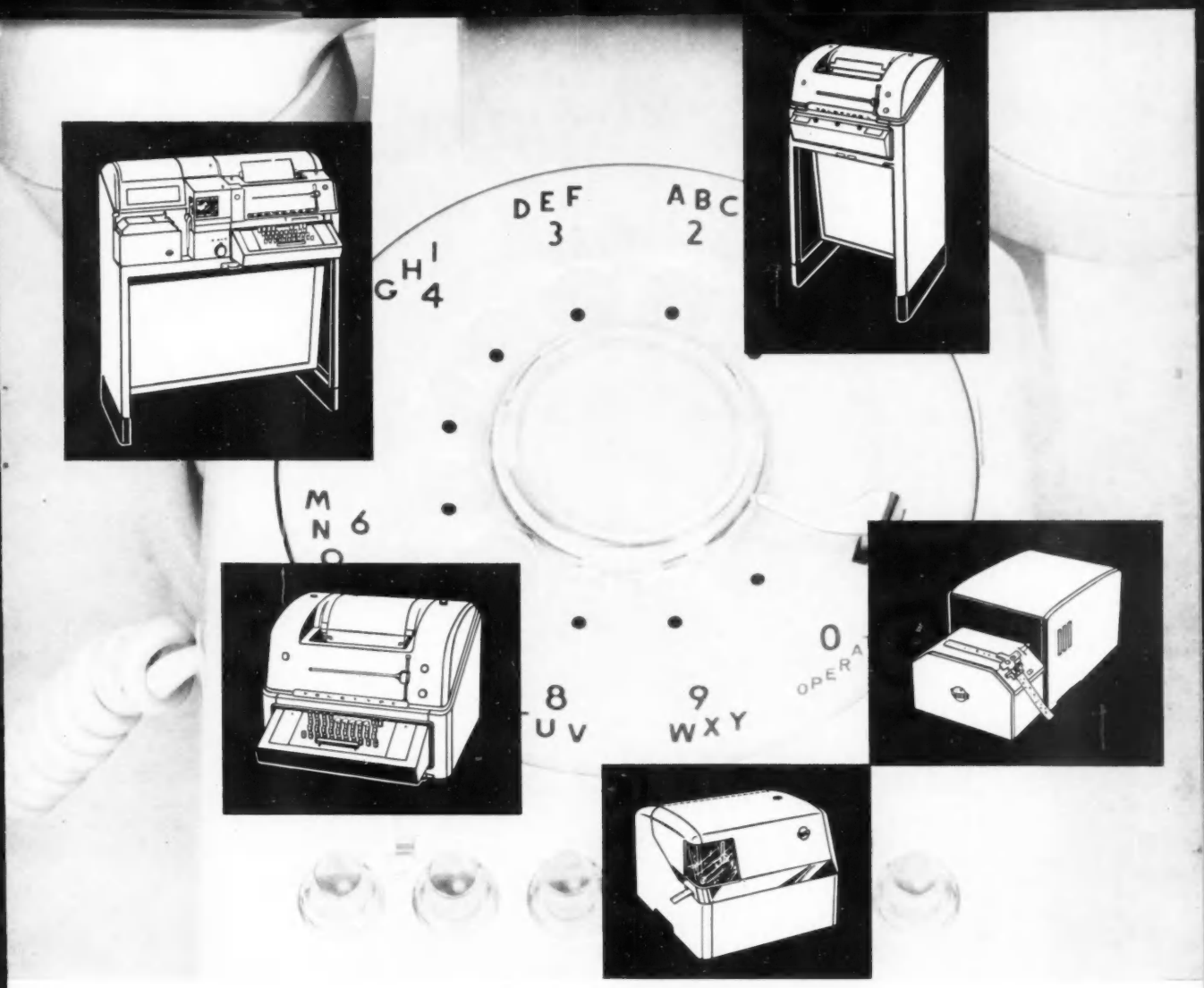
Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-14D, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

SUNNYVALE. PALO ALTO. VAN NUYS. SANTA CRUZ. SANTA MARIA. CALIFORNIA • CAPE CANAVERAL. FLORIDA • HAWAII



Teletype equipment in Data-Phone service

All Teletype sending and receiving equipment—page printers, tape punches and tape readers—can be used in Data-Phone service, the new Bell System method of data transmission via regular telephone lines.

Data can be speeded over local or long distance lines—to a single destination or to several destinations simultaneously. The data can be received on plain message paper . . . punched paper tape . . . or marginally perforated business forms of almost any size. And always there is a "home record" of what is sent.

Significant paper work simplification and time savings can be achieved in handling accounting and billing information, inventories, payrolls, invoices, sales orders, ticket pick-up and numerous other kinds of business detail. If desired, punched tape can be obtained as a by-product of both sending and receiving operations, for later use with business machines.

A growing number of firms are already using Teletype equipment over Data-Phone circuits. For example, companies that purchase large quantities of airline space place orders by phone, then receive tickets on Teletype printers right in their own offices. With this method, tickets are received faster, messenger service is eliminated, and records for accounting purposes are automatically provided.

Teletype Corporation manufactures page printers and tape units such as the Model 28 equipment illustrated above for the Bell System and others who require the utmost reliability from their data communications facilities.

If you would like to investigate the advantages of Teletype equipment for your business, write to Teletype Corporation, Dept. 21-F, 5555 Touhy Avenue, Skokie, Illinois.

TELETYPE®
CORPORATION • SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 75 ON READER SERVICE CARD

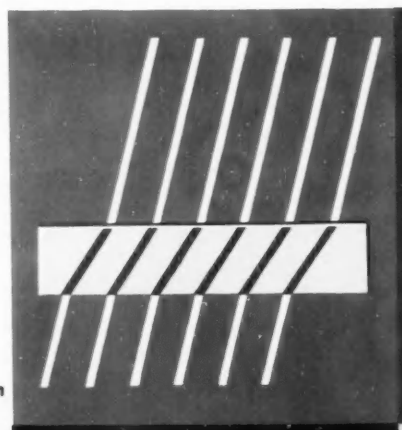
MSA Instruments apply all these principles for dependable process stream analysis

Gas Chromatography:

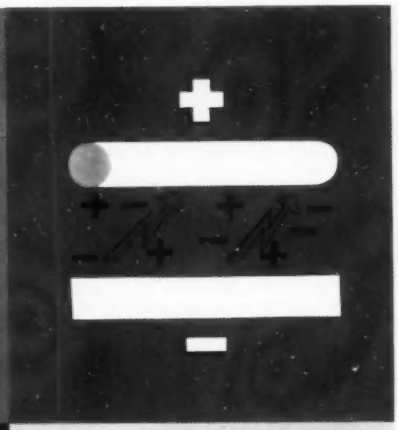
The versatile new M-S-A® Gas Chromatograph is a rugged process instrument designed to help you gain greater accuracy and flexibility in solving your process stream analysis problems. A tape-programmed control unit is the key to the gain in operating precision. It's first of its kind to be used for this purpose. • System consists of a motor-driven transparent film in conjunction with a photoelectric transmitter and receiver. They work together to provide you with any combination of time and sequence required. • Tape is a single continuous loop of standard 16 mm film. It's printed in 1-second graduations. Setting up a program is simple: just mark the tape with a lead pencil at appropriate intervals. Repeatability is to within 1/10 of a second. • Many more helpful approaches to measuring gas concentrations are available from MSA. Most of them stem from the principles symbolized on the next page. Write us for new bulletin on our Gas Chromatograph. Or for literature on any of our other process stream analytical instruments.



Mine Safety Appliances Company, Pittsburgh 8, Pennsylvania



Refraction



Ionization



M-S-A® Gas Chromatograph



M-S-A® LIRA® Infrared Analyzer Model 200



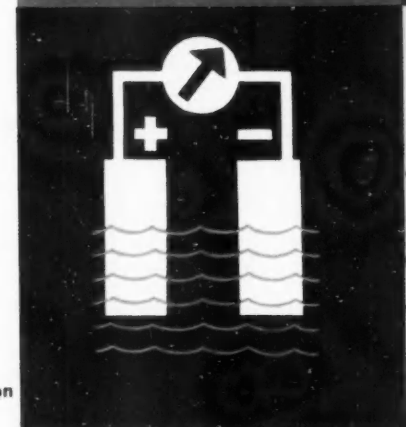
M-S-A® LIRA® Infrared Analyzer Model 300



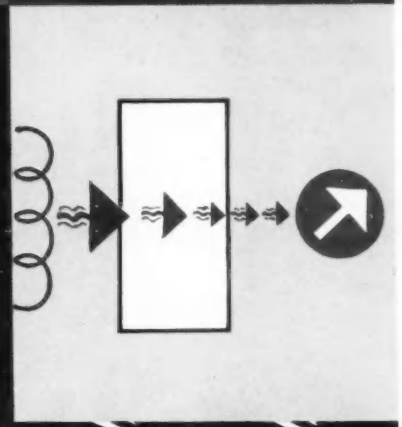
M-S-A® BillionAire* Analyzer



M-S-A® Process Refractometer



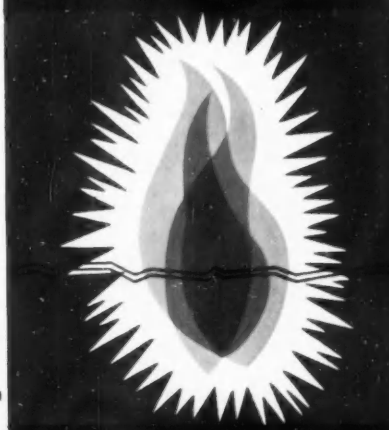
Depolarization



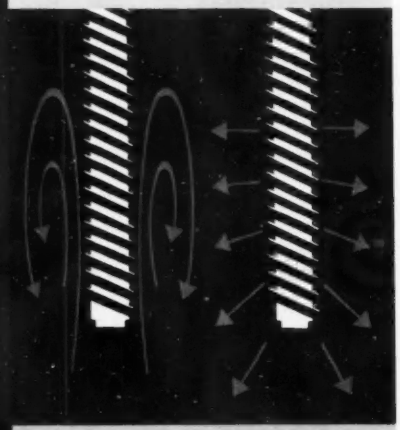
Infrared Analysis



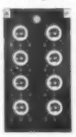
M-S-A® Inert Gas Analyzer



Catalytic Combustion



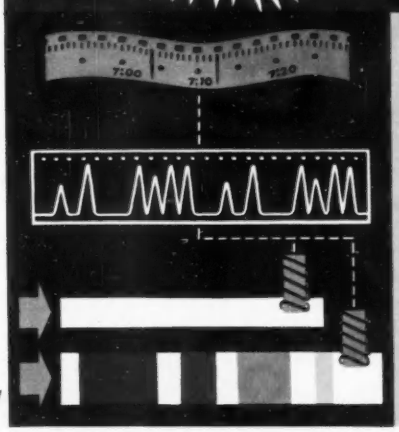
Thermal Properties



M-S-A® Combustible Gas Analyzer



M-S-A® Thermatron Analyzer



Chromatography

INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

MSA



M-S-A® Oxygen Indicator



M-S-A® Water Vapor Recorder

*Trademark

Solve Multi-Point Temperature Control Problems...

at ⅔ cost of competitive systems

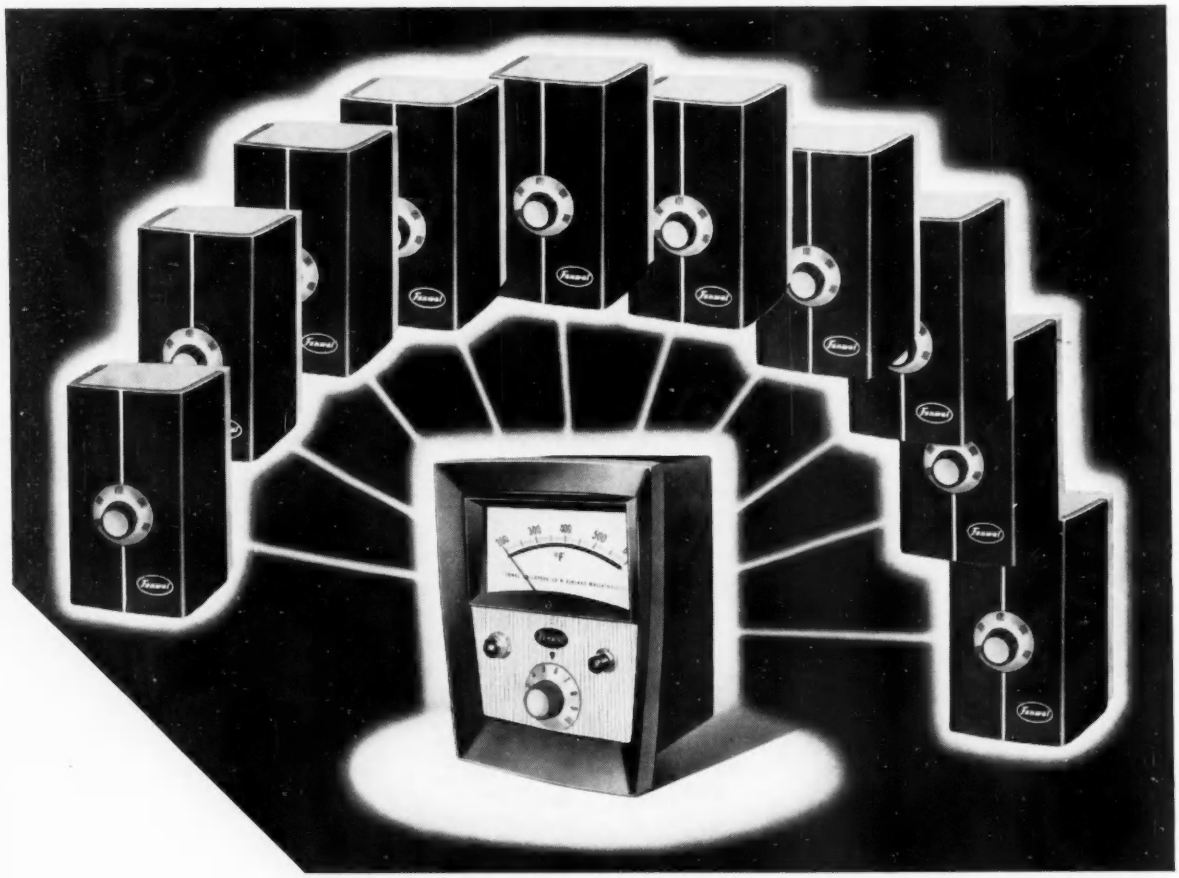
You get them all — wide ranging versatility . . . maximum sensitivity . . . easy installation and servicing! These features *combine* in a Fenwal 536-580 multi-point monitoring system to give you precise, transistorized temperature control and indication. And *you choose the features you need to suit your own requirements!*

Examine these cost saving advantages: Indication and control circuits are separate . . . the 536-580 system eliminates the need for separate indication and control at each point. You can build a control system concurrent with your needs — start with 2 points and build up to 10 points without paying a premium at the outset. The complete control system is built from *standard* catalog parts, thereby eliminating the need to buy costly "specials" for servicing at a later date.

Individual points can have either proportioning or ON/OFF control modes. The system permits "flick of switch" indication of from 2 to 10 temperatures. Individual set points can be adjusted from a central control panel or through a separate potentiometer remotely located. You select your own number of points and you *pay only for the options you use.*

Choose from five standard temperature ranges — from −50 to 600°F . . . expanded scales permit fine temperature adjustments and improved readability, and *the entire system gives you sensitivity to within 0.1°F.*

Both instruments are smartly styled to perfectly complement modern industrial machines and interiors. A Fenwal engineer will be glad to supply information on this system, or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 296 Pleasant Street, Ashland, Mass.

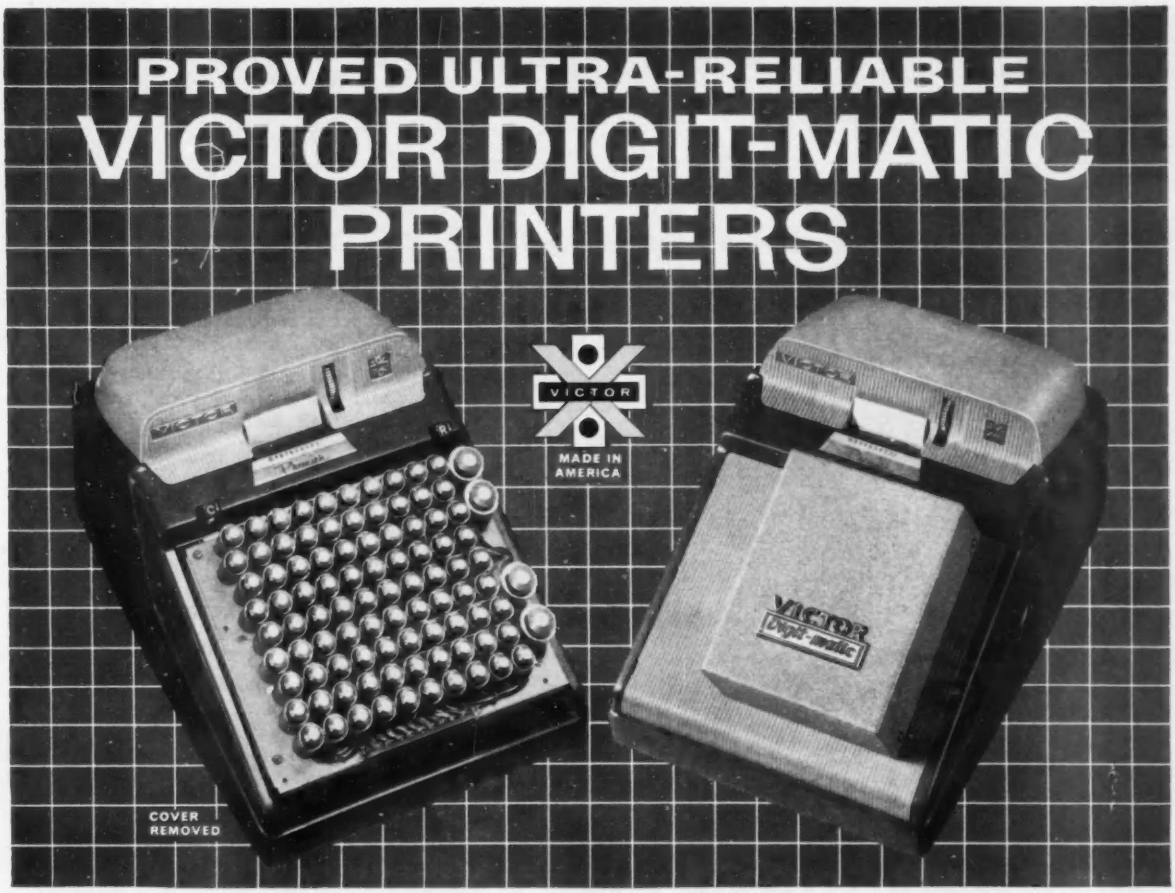


Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

← CIRCLE 69 ON READER SERVICE CARD

CIRCLE 70 ON READER SERVICE CARD

PROVED ULTRA-RELIABLE VICTOR DIGIT-MATIC PRINTERS



160,000,000 digit impressions without failure

Rugged, Trouble-Free—Digit-Matics are specially built to stand the strain of continuous operation. In a durability test, over 160 million digit impressions were made without breakdown or need of adjustment. The machine tested operated continuously, eight hours per day until 160 million digit impressions were made. During this period only normal lubrication and cleaning were performed.

Parallel or Serial Entry — Automatic and unattended, solenoid-activated Digit-Matics print out alpha-numeric data from remote equipment. High speed parallel entry models accept up to 10 digits at a time, print up to 4 lines per second. Serial entry models accept 1 digit at a time, up to 11 per line.

Two-Color Printing — Positive values in black, negative values in red. Ideal for "accept-reject" sequences, testing applications, accumulating data from two sources on one Digit-Matic, and many other uses.

Adaptable to Your Specific Needs — Line includes listers, accumulators and calculators. Versatile units can handle degrees, minutes, seconds, fractions. Other modifications: superimposed keyboard for manual use, time readings, counters, etc.

Immediate Field Service — 70 factory service branches and service representatives in over 600 cities assure uninterrupted operation. Victor offers 30-day delivery on most Digit-Matics. Mail coupon now for product data and application information.

VICTOR
ELECTRONICS DIVISION

Victor Adding Machine Co., Chicago 18, Illinois
Victor Adding Machine Co., (Canada) Ltd., Galt, Ont.

Manufacturers of Digit-Matic Printers, Scanning Printers, Electrical Keyboards, and Digit-Matic Data Punches

Victor Adding Machine Co. CE-6
Chicago 18, Illinois
Send full information on Victor Digit-Matics.

My application is_____

Name_____ Title_____

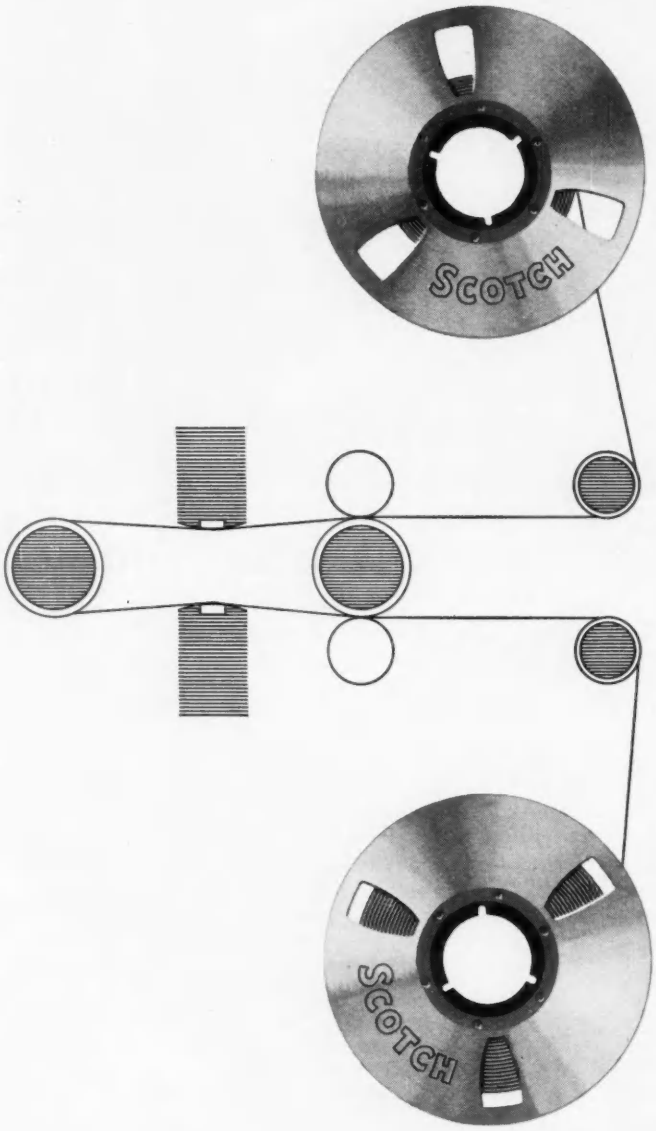
Company_____

Address_____

City_____ State_____

BEST SHORT WAVE LENGTH RESPONSE

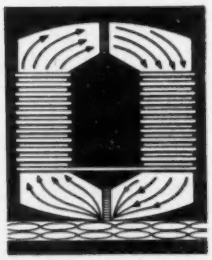
SCOTCH® BRAND High Resolution Tapes offer superior high frequency results



IN INSTRUMENTATION Tapes, a good *bit* may well depend on the character of the magnetic coating—and the uniformity with which it is applied. At short wave lengths, the head responds only to the flux nearest it—thus, the thinner the coating, the more it concentrates flux in that narrow region next to the gap where the head can use it best.

"SCOTCH" BRAND High Resolution Tapes 457, 458 and 459 testify to the great skill "SCOTCH" BRAND experts have in laying down a thin uniform coating that results in intimate head-to-tape contact, as shown in the diagram. This famous trio of tapes reproduces the critical short wave lengths, offers the superior response and resolution that lets you pack more information to the inch.

Much of their fine performance at high frequencies rests with the famed "SCOTCH" BRAND high potency oxides and their higher magnetic retentivity. At optimum bias settings, the coating is about 50% more sensitive to short wave lengths than ordinary coatings.



These tapes give you three great bases on which to build toward miniaturization. No. 458, with a 1.5 mil polyester base, offers standard recording time and maximum strength. No. 459, with a 1.0 mil polyester base, gives 50% extra recording time. No. 457, with a .65 mil base of tensilized polyester, delivers twice the standard recording time. One of the key factors in the consistent performance of the "SCOTCH" BRAND High Resolution Tapes is their uniformity—from reel to reel and within the reel. All three tapes offer a uniformity in magnetic coating and base that goes far to eliminate errors in performance.

In producing uniform tapes for all applications, nothing replaces the years of experience offered by the "SCOTCH" BRAND research and manufacturing team—the same team responsible for most tape advances. So check the entire "SCOTCH" BRAND line: Heavy Duty Tapes 497, 498 and 499 outwear ordinary tapes 15 times, even under adverse operating conditions. High Output Tape 428 offers top output at low frequencies. Sandwich Tapes 488 and 489 wear 30 times as long as ordinary tapes, cut head wear and oxide rub-off. And more reels of Standard Tapes 408 and 403 have been sold than any other kind.

Your nearby 3M Representative serves as a convenient source of information in all major cities. Contact him or write Magnetic Products Div., 3M Company, Dept. MBS-61, St. Paul 6, Minn.

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"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

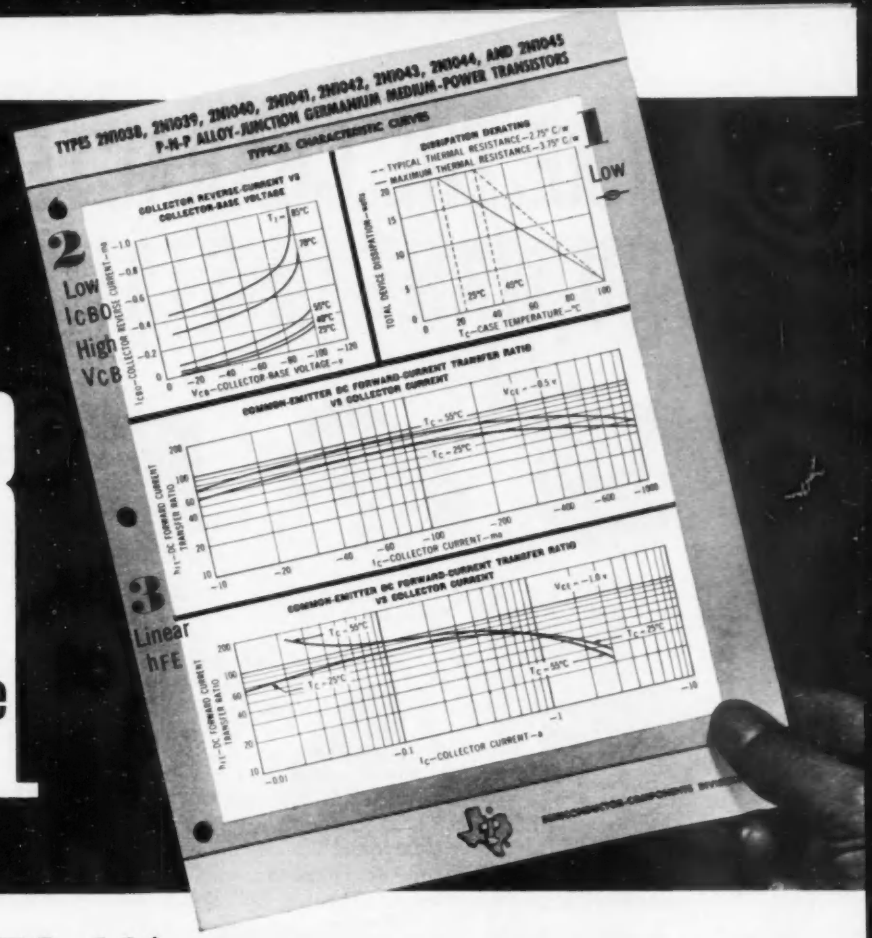
SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



Cool Operation
Medium Power
Linear Beta
4. Minimum Space

ALL IN ONE TO-11* PACKAGE—TI 2N1038 SERIES

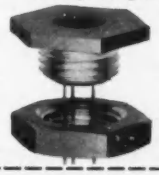
1. 20 w dissipation in a TO-11 package (with flange or stud heat sink) — maximum heat transfer for greater circuit economy and longer, more reliable component life.

2. Guaranteed maximum I_{CBO} as low as -125 μa and minimum V_{CB} as high as -100 V — in a TO-11 package to give you the useable power you need for the widest range of driver requirements.

3. Linear h_{FE} over a wide range of current conditions (-10 ma to -3000 ma) increases P_{IN} vs. P_{OUT} ratio — extending design flexibility.

4. Highest power/size ratio devices available today — Texas Instruments 2N1038 germanium transistors give you *useable* power, *economical* circuits, *compact* designs — all with a TO-11 package. Plus, mechanized production processes assure you *constant-predictable* performance and immediate large quantity availability.

Three packages for your design assistance—at no extra cost



FLANGE or **STUD** for highest dissipation and for easiest mechanical assembly.



STANDARD for most compact design.



■ **Use-proved in sustained satellite power supply operations.**

■ **Less than 7.8 grams and 0.59 square in. Less than 0.39 in. high.** ■ **Up to 20 watt dissipation in flange or stud heat sink.**

**with 0.025 in. diameter lead*

Device	2N1038	2N1039	2N1040	2N1041	2N1042	2N1043	2N1044	2N1045
I_C	1 amp	1 amp	1 amp	1 amp	3 amp	3 amp	3 amp	3 amp
BV_{CBO}	40	60	80	100	40	60	80	100

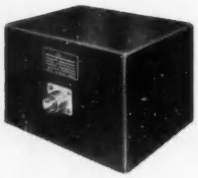
Write today or call your local TI Sales Engineer or TI Distributor for price and technical information, including applications assistance.

SEMICONDUCTOR-COMPONENTS DIVISION
PLANTS IN DALLAS, TEXAS
BEDFORD, ENGLAND
AND NICE, FRANCE

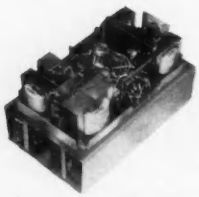
TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O. BOX 5012 DALLAS 22, TEXAS

CIRCLE 73 ON READER SERVICE CARD 18113

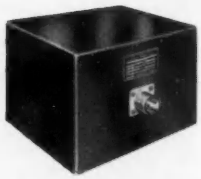
NAME THE CHARACTERISTICS* YOU WANT IN STATIC POWER



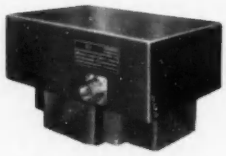
* Large Overload Capacity: 200%



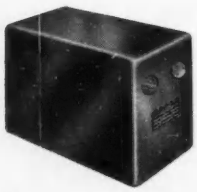
* Low Power Factor: 0.3 lagging to unity



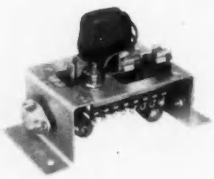
* Dual Output: Single or Three Phase



* Wide Temperature Range: −55° C to +125° C



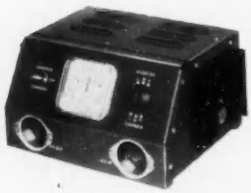
* Accurate Frequency Regulation: 400cps. ± 0.25%



* High Efficiency: 85% minimum



* High Voltage Output: 150 KV



* Dual-Purpose: Charger and Inverter

...for • industrial telemetry systems • remote or emergency signalling, warning or measuring systems • automated machine tools • microwave communication equipment

... wherever circuit interruption cannot be tolerated

You probably would not need all of the design/performance characteristics listed above in a single inverter. But today, after a three-year, full-scale development program, Hamilton Standard static inverters offer a wider range of proven design and operating characteristics than any you can buy—individually and in combinations. This means that Hamilton Standard static inverters can deliver the extra reliability, long maintenance-free service and quick starts heretofore unattainable with rotary power supplies.

If your equipment calls for a power supply with exceptional reliability, tell us about your complete requirements. We can provide the inverter you need.

What are inverters ... how, when and where to use them. A comprehensive aid for engineers. For your copy, write: Hamilton Standard Electronics, Broad Brook, Conn.



UNITED AIRCRAFT CORPORATION

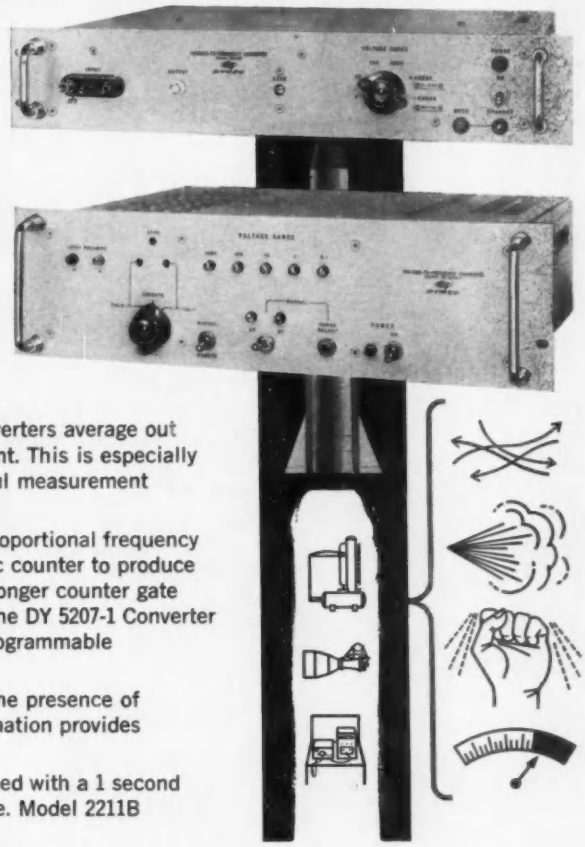
HAMILTON STANDARD DIVISION

ELECTRONICS

HERE'S ECONOMICAL, SIMPLE ANALOG/DIGITAL CONVERSION *for accurate systems measurements*

DYMEC VOLTAGE-TO-FREQUENCY CONVERTERS—

building-block instruments for high-accuracy voltage measurement, independent of noise or hum



Dymec Models 2210 and 2211A/B Voltage-to-Frequency Converters average out noise and hum to obtain high-accuracy voltage measurement. This is especially advantageous in systems applications. You get higher useful measurement accuracies than with other conversion techniques.

Models 2210 and 2211A/B convert an input dc voltage to a proportional frequency of constant amplitude which is applied to a gated electronic counter to produce a direct digital reading of the input analog voltage. With a longer counter gate time you also can obtain the integral of the input voltage. The DY 5207-1 Converter permits similar measurement of ac input voltages and is programmable for both dc and ac voltage measurements.

In addition to flexible systems use, especially effective in the presence of ac input interference, the Dymec Converter/Counter combination provides an inexpensive digital voltmeter for lab or factory.

Models 2210 and 2211A provide four-digit resolution when used with a 1 second counter gate or three-digit resolution with a 0.1 second gate. Model 2211B provides up to 5 digits of resolution.

Here are brief specifications of Dymec Voltage/Frequency Converters. Call your Dymec/Hewlett-Packard representative or contact Dymec direct for detailed data sheet and application information.

	Dymec 2210/2210R	Dymec 2211AR/BR	Dymec 5207-1
Ranges: (VDC, ±, full scale)	±1 ±.1 ±10 ±1 ±100 ±10 ±1000 ±100 *	±1 ±.1* ● ±10 ±1 ±100 ±10 ±1000 ±100 *	DC: ±.1 1; ±1 10; ±10 100; ±100 750; ±1000 — AC volts, rms, 20 to 100,000 cps
Output Frequency:	0-10 KC	2211AR, 0-10 KC 2211BR, 0-100 KC	0-10 KC
Accuracy:**	±0.06%	2211AR, ±0.02% 2211BR, ±0.03%	±0.06% dc ±0.5%, 50-10,000 cps ±0.75%, 20-100,000 cps
Stability:***	— ±0.03%	±0.02%	±0.03% dc
Price:	DY 2210, $660.00 (cabinet) DY 2210R, $650.00 (rack)	$1,250.00 (rack)	$1,850.00 (rack)

*Available at extra cost. **Accuracy includes stability, is given in per cent of full scale and is affected by frequency and accuracy of calibration, line voltage variations, temperature changes and accuracy of multi-range input attenuators. Figures given are those attained under normal operating conditions. ***Given as per cent of full scale per 24-hour day.

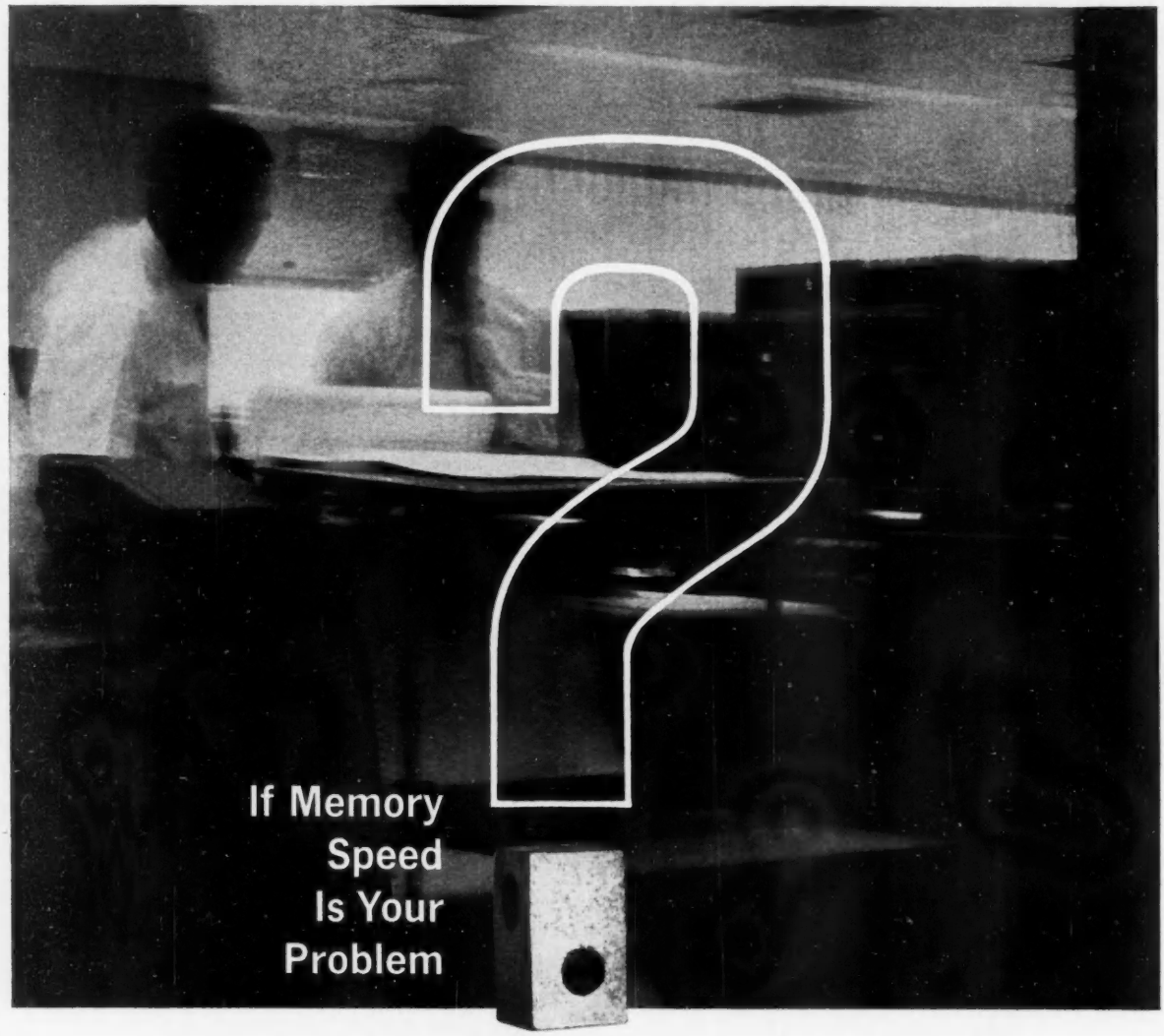
Data subject to change without notice. Prices f.o.b. factory.

DYMEC

A Division of Hewlett-Packard Company

Dept. C-62, 395 Page Mill Road, Palo Alto, California • DAvenport 6-1755 (Area Code 415)

TWX-117-U



BIAX MEMORIES are the answer

Aeronutronic's BIAX INSTRUCTION MEMORIES will increase the speed of your computer, data handler, or control system. These remarkable memories operate at high speed, with non-destructive read, low power, and high reliability.

BIAX MEMORIES offer access time of 0.4 μsec and cycle time of 1.0 μsec without need for regeneration. These advanced memory systems will give you the necessary speed and reliability for all your program storage.

Specifications

Up to 1024 words
Up to 36 bits per word
Read cycle time: 1.0 μsecond
Access time: 0.4 μsecond
Loading: From paper tape or your equipment at rates up to 200 kc
Power: Less than 50 watts
Temperature: 0°C to 50°C

BIAX MEMORIES are available in several standard sizes or can be built to your specifications on a fixed price basis. Their low power requirements plus high reliability over a broad range of environmental conditions assure dependable performance.

For further information regarding BIAX MEMORIES' capabilities applicable to your requirements you are invited to write or call: Manager of Marketing, Computer Products Operations, Department 28.

AERONUTRONIC
DIVISION
Ford Motor Company
NEWPORT BEACH, CALIFORNIA

CIRCLE 76 ON READER SERVICE CARD

CIRCLE 77 ON READER SERVICE CARD→

Fischer & Porter's

NEW IN-LINE BLENDING SYSTEMS

MIX FLUIDS RIGHT IN A PIPELINE

Eliminate batch mixing, holding tanks, trimming

Control total quantity ratios by an electronic "memory"

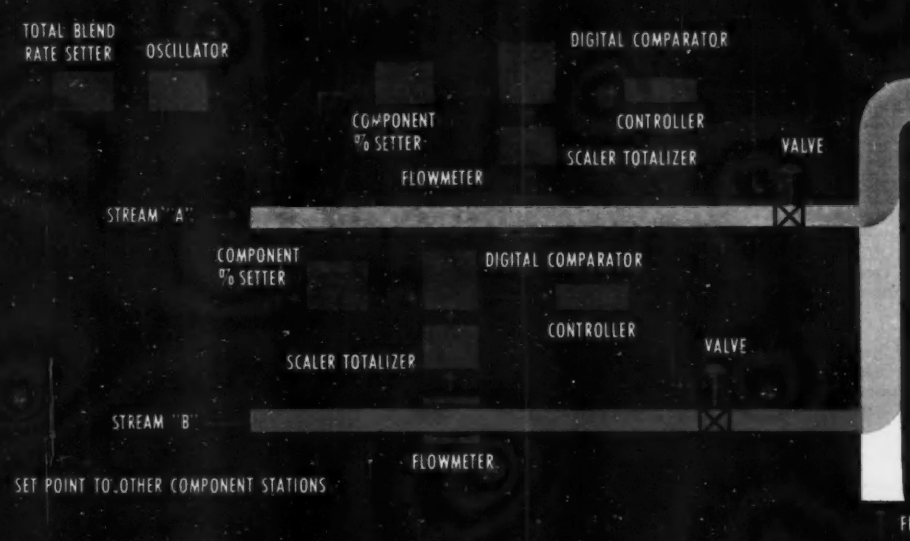
Give a system accuracy of better than ±½%

These new electronic In-Line Blending Systems let you blend two or more fluids — automatically and continuously in a pipeline — with greater accuracy than ever before. Each system combines flowmeters, interchangeable transistorized readout devices and electronic control units to give you a complete, packaged, blending facility from a single source — Fischer & Porter Company.

Each of these unique systems has a memory — that is, it "remembers" how much of any one ingredient has been added to the main stream. Then it goes on to compensate, continuously, for any deviations from the required total blend ratio, whether plus or minus, with an accuracy better than ±0.5%, a repeatability better than ±0.2%. And it is this memory characteristic which obsoletes older flow rate ratio methods.

Result: fast, precise, flexible systems that enable you to control mixing or blending from feed lines to point-of-use — product pipelines, tankers, whatever. You eliminate wasteful batching operations in between. Many types of systems are available, including the blending of two or more streams for petroleum, chemical, food, or other products of processing industries.

A description of your interests will bring you complete technical data. And, let us know if you would like to see a typical system in operation here at the plant . . . Fischer & Porter Company, 761 County Line Rd., Warminster, Pa. In Canada, write Fischer & Porter (Canada) Ltd., 2700 Jane St., Toronto.



Typical multi-stream In-Line Blending System. All systems are electronic with measurement, control, and readout functions handled by interchangeable modules.

FP FISCHER & PORTER COMPANY

A world-wide Instrument Company with plants in Australia, England, France, Germany, Holland, Mexico, and the United States.





EGAD, METHINKS YON DESIGN ENGINEER HATH GONE STIR-CRAZY! *HOW COMETH?*

Ah, thereby hangs a tale, sire. He needs a time-delay relay with a range from 15 seconds to 30 minutes — or even longer! — yet one with a repeat accuracy of plus or minus 2 per cent of the overall time range.

Simple.

But there is more. He demandeth a reset time of thirty milliseconds! His specs are stringent beyond belief. His is a military problem —

Simple.

Speak not in haste, milord. 'Tis hush-hush stuff. All one may say is that he *might* be working on radio, radar, camera control, guided missile, flasher, gun purge-door, fire control —

Hah, still simple, say I. Obviously the fellow doth need an accurate delay between the closing of a control circuit and the actuation of an independent load switch or two. For Cramer's new TYPE 432 Time Delay Relay, such work is child's play! Know ye not that TYPE 432 hath passed such severe *Mil* tests as operation at 70,000 feet, vibration at 10G peak acceleration from 10 to 2,000 cps, and 50G 11-millisecond shock?

Great Caesar's ghost!

Of a certainty, the unit is hermetically sealed against dust, humidity, salt spray. It is rugged —

But bulky, no doubt. Ah, me!

Not so. TYPE 432 *miniature* is lightweight, amazingly compact. And why? Because Cramer doth use newly designed 400 cycle and 60-cycle motors, not to mention all manner of ingenious, miniaturized components.

Yet you say it is *rugged?*

Ho, ho. With a *minimum* switch life of 50,000 operations! And yet —

And yet — ?

I perceive that this design engineer hath a dual problem, for he also needs a cycle timer to control a repeated sequence of operations in a definite time relationship.

'Tis true. *Now* doth the problem confound the Cramer people?

Nay, nay. Cramer's new TYPE 553 Miniature Cycle Timer is practically a twin of the TYPE 432 Time Delay Relay, and offers an unsurpassed range of programming periods, from 5 seconds to 30 hours.

Happy day! I fly with these glad tidings to yon design engineer —

Better yet, methinks, inform the lad that he should get all the facts straight from the — er — horse's mouth, in a manner of speaking. Have him write for Cramer's data-filled Bulletins: PB-553 and/or PB-432. Therein are all questions answered, all problems solved.

CRAMER TYPE 432 MINIATURE TIME DELAY RELAY

Number of Poles 1 and 2 (standard).

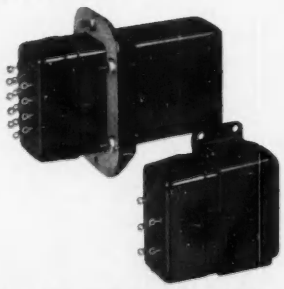
Time Ranges 15 sec to 30 min or longer.

Accuracy ±2% of overall time range.

Switches Fast make fast break, SPDT, rated 3 amps resistive and inductive at 125v ac and 30v dc.

Motor 400 cycle (hysteresis) 115v, 2 watts input; or 60 cycle (permanent magnet) 115v, 2 watts input. DC 26v ±4v using inverter.

Mounting Flange or bracket.



CRAMER TYPE 553 MINIATURE CYCLE TIMER

Number of Poles 5.

Time Ranges 5 sec (single pole) to 30 hours.

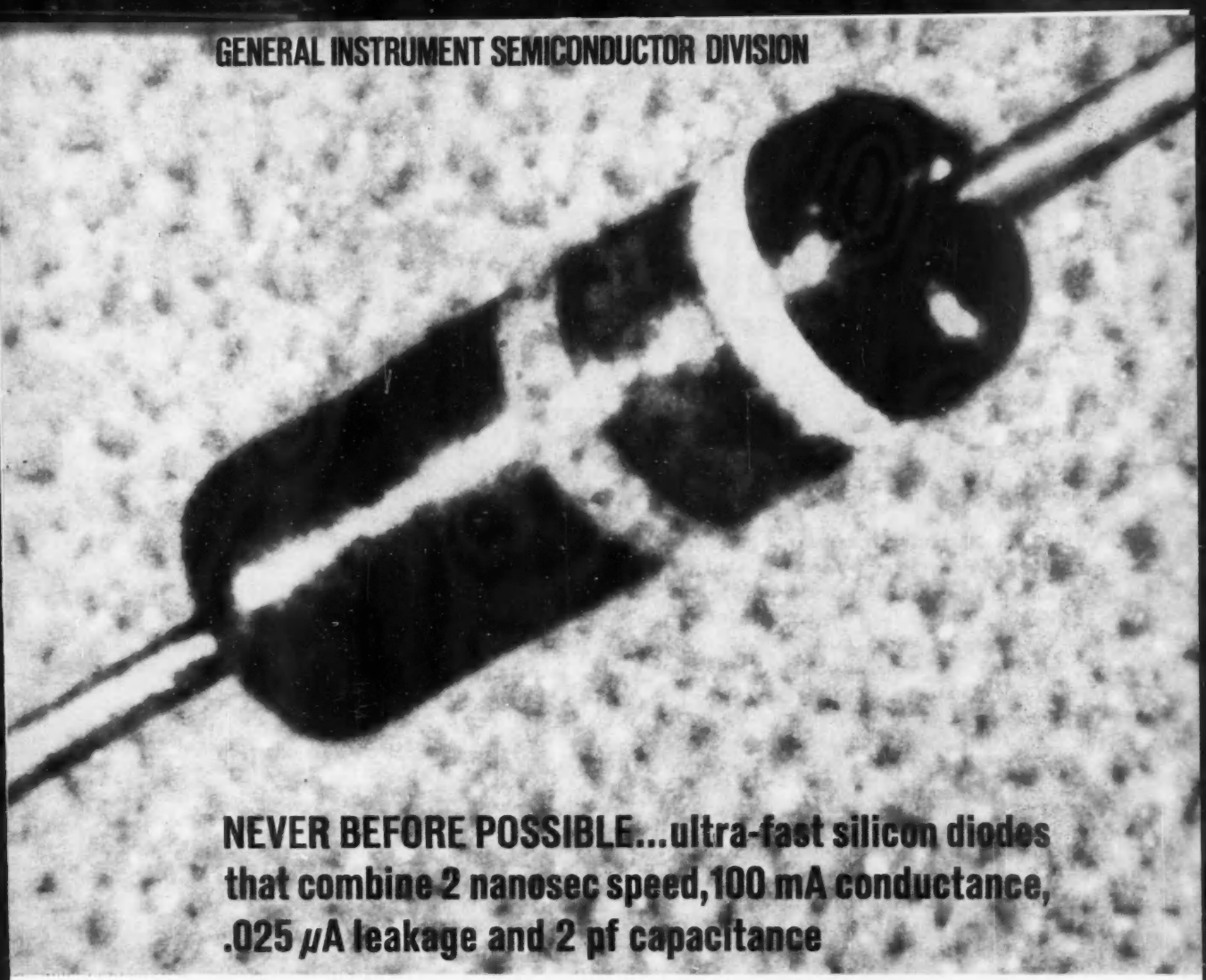
Accuracy ±0.5% of overall time range.

Switches, Motor and Mounting Identical to 432.

CRAMER CONTROLS CORPORATION

ELECTROMECHANICAL DIVISION • CENTERBROOK, CONNECTICUT

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION



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The new General Instrument 'SP' series offers a combination of electrical characteristics never before possible in ultra-fast switching silicon diodes. The complete line, including the popular IN914, IN916 and IN903 series, are immediately available in production quantities. They all feature nanosecond switching speeds, coupled with either high conductance, low leakage current or low capacitance. Check the chart. Then call the General Instrument sales office or franchised distributor nearest you for complete specs. Or write today to General Instrument Semiconductor Division, 65 Gouverneur Street, Newark 4, New Jersey.

TYPE	Breakdown ① Voltage (BV)	Maximum Reverse Current (μA) 25°C	150°C	Test Voltage ②	Forward Current (Min. mA @ IV)	Reverse Recovery Max. (mμsec) ③	Capacitance at V_R=0 (pf) ④	Rectification ⑤ Efficiency
SP100	75	0.1	100	50	10	2	2	45%
SP101	30	.025	50	20	100	2	2	45%
SP106	125	.025	50	100	100	2	2	45%
IN914A	100	.025	50	20⑥	20	4	4	45%
IN916A	100	.025	50	20⑥	20	4	2	45%

① Breakdown Voltage at 100 μA. ② Voltage at which Reverse Current measurements were taken. ③ Switching I_F= 10 mA to V_R=6.0 V R_L=100 ohms recovery to 1 mA. ④ Measured at 1 megacycle. ⑤ Measured at 100 megacycles using MIL-STD-19500 test circuit. ⑥ Reverse leakage when measured at −75 Volts and 25°C shall not exceed 5 μA.

ACTUAL SIZE

GENERAL INSTRUMENT CORPORATION

CIRCLE 79 ON READER SERVICE CARD

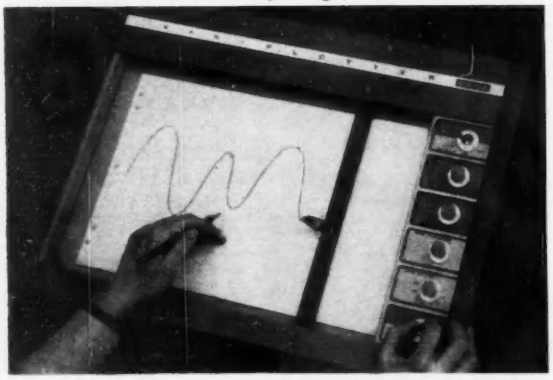
HOW DO YOU TEST AN X-Y PLOTTER



In an automobile, transmissions can be designed to give top speeds by sacrificing acceleration—but it's a poor bargain, as a quick road test will show. Similarly, in an X-Y analog plotter high slewing speeds can be obtained by sacrificing acceleration. Again it's a poor bargain because highest plotting accuracy depends upon high static accuracy combined with a *perfect balance between acceleration and velocity limits.* EAI's Model 1100E Variplotter has this desired balance as a simple 'road test' developed by EAI engineers can graphically demonstrate.

As a matter of fact, everything about the Model 1100E Variplotter has been engineered to give you the utmost in plotting performance. Developed to speed up engineering control, testing and design operations, it consistently produces faster, more accurate plots of X-Y related data.

The development of the Model 1100E has resulted from EAI's years of pioneering research and development in the field of automatic plotting. It provides outstanding accuracy of 0.075% F.S. – less than the width of the line drawn by the pen. Arm acceleration is 250 inches/sec.^{2}. Pen acceleration is 750 inches/sec.^{2}. The high velocity of the 1100E is augmented by this faster acceleration to assure outstanding dynamic performance.



Repeated testing under actual operating conditions proves that the principle of the Variplotter, Model 1100E design virtually eliminates backlash, and provides drift-free operation for periods of 8 hours or more. This superior repeatability has been amply testified by users who report that even after overnight shut-down, the Model 1100E resumes plotting with no noticeable drift.

A complete line of accessories—including bi-variant function generator, digital data plotting (manual or automatic) and time base generator—makes the EAI Variplotter the most versatile automatic plotting method available. The Model 1100E can be easily converted to operate as a function generator—or will plot digital information manually from a keyboard as well as automatically from punched cards or paper tape—by simple addition of compatible components.

Check these features...

Portable desk-top size—
Large plotting surface (11" x 17")—
Vacuum hold down—
High dynamic and static accuracy—
Rugged construction—
Ease of maintenance—
Differential input—
Plug-in input network—
Superior repeatability.

Ask your EAI representative to show you the simple laboratory test that proves the superiority of the Model 1100E Variplotter,—or write for Bulletin AP 810-1.

EAI ELECTRONIC ASSOCIATES, INC.

Long Branch, New Jersey



1961 Numerical Control Survey

Disappointment

Sales of numerical control systems for machine tools are not quite living up to expectations. That's the conclusion reached in Control Engineering's 1961 survey of suppliers. CtE asked 38 suppliers to predict 1961 NC sales; added up these total estimates:

- 1,090 point-to-point systems with a total value of $13,080,000 will be sold.
- 260 continuous contouring systems with a total value of $9,100,000 will be sold.
- Total numerical control systems to be sold in 1961: 1,350; total market—$22,180,000.

At first glance this looks like a nice increase over 1960 estimates, when suppliers expected to sell 985 point-to-point systems and 130 continuous contouring systems (CtE, Oct. 1959, p. 75). The 1,350 systems represent a 22 percent increase over 1960.

Although sales of continuous contouring systems are growing rapidly—estimates are up 100 percent over last year's expectations—the big disappointment is in point-to-point system sales, which, representing the bulk of systems, gained only 11 percent. What makes this figure so disappointing is that many suppliers expected the sale of point-to-point systems to double this year.

Missed factors

Last September at the National Machine Tool Builders once-every-five year show, only a pessimist would say the industry wouldn't sell 2,000 numerical control systems in 1961. Certainly numerical control was the outstanding feature of the show. But marketing men particularly missed two important factors:

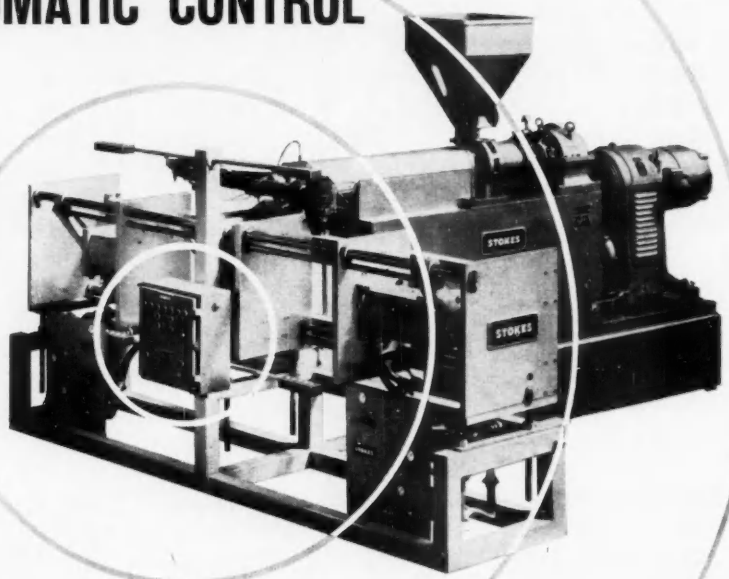
- machine tool sales did not respond to the stimulus of the show.
- the conservative nature of machine tool buyers.

Business slump

After a slight jump in sales in the autumn, machine tool orders slipped back to the doldrums that have plagued the industry since 1958. Last year's machine tool purchases dropped about the same as capital investments, about three percent. The first quarter of 1961 was even worse. But as business turned up in April (see page 179), numerical control sales started to spurt. In mid May, a machine tool sales manager told CtE that after a terribly slow start in 1961, he had "received six orders in the past ten days" for a numerically controlled machine that cost over $150,000. It now looks as if numerical control sales will improve sharply as the general business climate improves.

One factor that could distort the rosy picture: the military is buying continuous contouring controls again. These sales might not be repeated next year.

AN INDUSTRIAL TIMER FOR AUTOMATIC CONTROL



At the heart of the new, high capacity STOKES BLOW MOLDER

The production of hollow plastic articles (containers, dispensers, etc.) has been boosted immeasurably with the development of "High Capacity Stokes Dual - Manifold Blow Molder".

And at the heart of the system is an Industrial Timer Corporation timing device to provide the precise control of each cycle of processing.

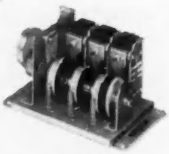
Wherever precise timing controls are required in industrial processes, or in equipment, Industrial Timer Corporation has the wide range of instruments, the wide experience in applying them, that assure the perfect answer to your problem.

If timing is of the essence . . . take the time to consult an Industrial Timer expert.

Phone or write us.



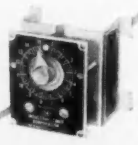
RUNNING TIME METERS



RECYCLING TIMERS



INTERVAL TIMERS



TIMER DELAY TIMERS

INDUSTRIAL TIMER CORPORATION

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CIRCLE 82 ON READER SERVICE CARD



Machine tool buyer conservatism is not so easily overcome. Says John Joerger, Sales Manager, Kearney & Trecker, "A numerically controlled machine tool is not bought today; it is sold. And it is not sold until it is successful."

Frank Fields, President of Fosdick Machine Tool Co., says "Machine tool users still don't understand the implications of numerical control. Only a few manufacturers are taking advantage of the huge savings available through numerical control."

Proving justification

One problem has been that many of these savings accrue from indirect sources that are tough to pin down—such as savings in floor space, inspection cost, lead time, and improved quality. It takes long investigation to prove these. And many veteran machine tool men say the case for numerical control is not as clear cut as suppliers profess.

Winning the battle

That the suppliers are slowly winning their battle is evident. When several numerical control suppliers told CtE editors that the Norton Company in Worcester, Mass. was one company that wouldn't buy numerical control despite their heaviest selling guns, CtE called to find out why. The magazine learned from factory manager H. T. Price that Norton has just purchased its first point-to-point system. Said Price, Norton has been interested in numerical control for two or three years. Key executives have been going to NC seminars, teaching themselves about it, and trying to find ways to justify the equipment. Then, too, the company spent a lot of time studying all the many different systems offered. All this study finally paid off in a purchase. More will follow.

One numerical control sales manager is looking for a chain reaction from such comprehensive investigations. He feels that once a NC machine is installed, the user will be so satisfied that the installation will trigger reorders *plus* sales of three or four units from others who hear about it.

Dark days past?

Only time will tell whether the numerical control industry has seen the last of its dark days. In the past year, several companies have been forced to curtail their activities in the field, or drop NC systems completely. For example, Modern Engineering Service Co. has terminated the manufacturing of its point-to-point system. Minneapolis-Honeywell, which used to offer numerical control says, "We are not in a position to offer tape control systems at this time." Another organization that appeared ready to be a major factor in NC 18 months ago is now up for sale by a disillusioned management.

But probably the blackest news for one manufacturer was the word that the Air Force's Air Materiel Command was replacing that company's controls with competitive ones because of unsatisfactory performance.

That is an indication that all troubles the machine tool suppliers have had have not been marketing ones.



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THE EXTRA INSURANCE OF 100% TESTING OF ALL PRODUCED UNITS!

Tests and sorts at the incredible speed of 3600 transistors per hour. To you concerned with reliability this is *extra insurance* that you receive unmatched quality and reliability.

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TRANSISTOR CENTER U.S.A.

Control
ENGINEERING

JUNE 1961

Reliability? Progress? or Both —

Control and computer systems incorporating many thousands of components have taken over key operations for the military and are rapidly moving into industry. To be effective these systems must be reliable, and to be reliable the reliability of the components and subsystems must be known and the system designed to compensate for potential transient or catastrophic failures that could destroy the system's effectiveness. As a result both industry and the military are taking steps to demand proof of reliability from their suppliers.

Evidence of this is shown in the report of the Ad Hoc Study Group on Parts Specification Management for Reliability of the Department of Defense (commonly known as the Darnell Report). Among other things this report recommends that defense procurement specifications include quantitative reliability specifications that must be met by suppliers of electronic components. To become an approved source the supplier must furnish proof that his devices exceed this minimum reliability, and to maintain his position he must continue to offer reliability data at specified intervals. This adds considerable expense that must finally be borne by the user, and leads to maximum use of standard preferred parts since proof of reliability of new devices is extremely difficult.

In some cases industry is reaching the same end via a different route. A user of process monitoring systems, for example, writes his specifications so that only third generation production components and modules are acceptable, where to be considered a successive generation equipment must utilize essentially the same circuit design, components, and layout as the previous generation. This approach undoubtedly leads to improved reliability, again essentially through the use of standard preferred parts.

The danger is that the search for the ultimate in reliability by the use of proven standard parts may cause us to overlook vast potential gains from new devices and techniques. No designer or user of control systems should ever bury his head in the standard parts cook book. Some avenue must be kept open for the consideration of new fresh ideas. If the new approach is no good this time it may be the next, and at the same time an active interest encourages the supplier to continue to invest his time in the pursuit of new reliable devices.

Byron Ledgerwood

Just *Plug it in*

any computer and...

- **multiply**
- **divide**
- **square**
- **extract square root**

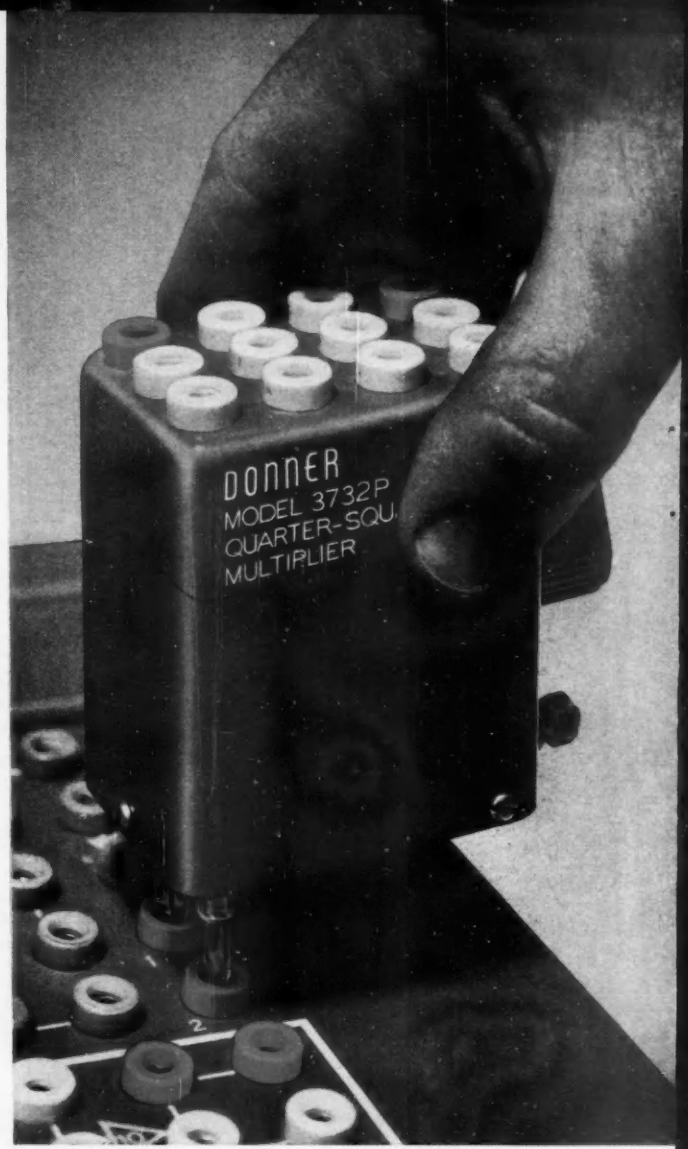
Donner's new all solid state electronic multiplier plugs into any analog computer problem board with ¾" terminal spacing – all Donner models, all Heathkit models, Boeing (BEAC), Goodyear L3-N3 series, and so forth.

Designed on the quarter-square principle, this compact, single channel multiplier offers four modes of operation selected by a switch:

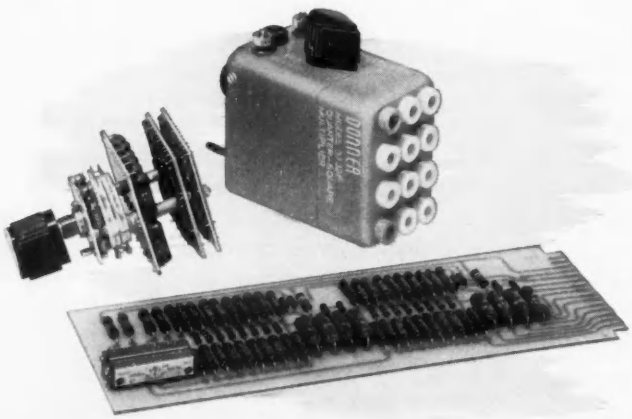
- Four-quadrant multiplication (output = $-0.01XY$), with static accuracy of 0.3% of full scale voltage (200 volts).
- Two-quadrant division (output = $-100X/Y$).
- Two-channel squaring (outputs of $-0.01X^2$ and $+0.01Y^2$).
- Two-channel square root operation.

As inputs, the Model 3732 accepts +X, −X, +Y, −Y, and generates an output current to the summing junction of an external amplifier.

To satisfy your particular needs, Donner furnishes the multiplier in a variety of packages besides the plug-in version shown.



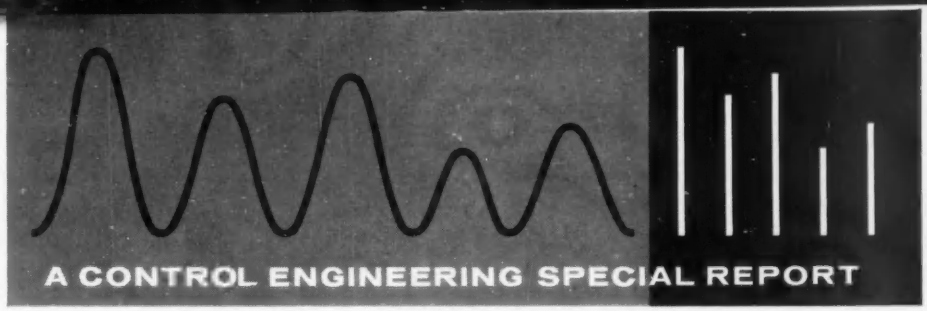
Model 3732 electronic multiplier is available without enclosure for panel mounting or as a single printed card for inclusion in your system. The unit is also available with up to three solid state multipliers on a 3½" x 19" panel for rack mounting.



Price of the Model 3732P is $350; delivery 30 days. Other prices, detailed specifications and demonstrations available from all Donner representatives or just drop us a line at the factory. Please address Dept. 21

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CIRCLE 86 ON READER SERVICE CARD



Industrial Process Chromatographs

HARRY R. KARP, Control Engineering

Process chromatographs carry out automatic determinations of the concentrations of components in plant streams. In the five or six years since the first commercial in-plant chromatographs were tried out, it is estimated that nearly 1,500 such analyzers have been installed in chemical, petroleum, food, metal heat treating, and other plants. Many chromatographs operate directly into conventional closed-loop control systems and into closed-loop computer control systems.

The experience gained over the past years by users and makers of chromatographs can only benefit future users. For one thing, customers can now choose in-plant chromatographs from the product lines of six analyzer makers. These manufacturers have pursued the important goals of extending sensitivity and reducing analysis time. Chromatographs can now detect trace elements in the parts per billion range and effect a multicomponent analysis in several seconds.

For another thing, users who will soon try chromatography for the first time stand to gain from the experience of other control engineers gleaned, for example, from such routine applications as measuring composition of deethanizer, depropanizer, and butane splitter streams.

Even though a chromatograph performs well as an instrument, success of any installation rests on user knowledge and cooperation.

Beckman's William Bierbaum expressed substantially the same viewpoints as other makers questioned about the user's role in successful chromatography. "One main problem is getting complete stream data from the customer. When complete analytical data is not available we encourage the user to send us a representative sample from his stream, not a synthetic sample. It must be realized that account has to be taken of every component in the stream even if there is no need or desire to measure it. When we know in advance that offending components, such as ones that polymerize, exist in the stream we can application-engineer the analyzer to eliminate them.

"Some customers, we find, don't realize that analyzers are only as good as the sample handling that precedes them. They should buy a completely assembled sampling system from the chromatograph maker, if possible.

"Lastly, chromatographic analyzers—while comprised of many elements already familiar to instrument department personnel—are quite complex and do require some maintenance and periodic checking to keep the analyzer running properly. However, we have found that explaining the principles of chromatography in general and of analyzer operation in particular soon dispels any doubts about the equipment's ability to remain on-stream for extended periods."

HOW PROCESS CHROMATOGRAPHS WORK

Chromatography is a separation technique. Molecules in the sample stream separate as they traverse paths that favor the migration rate of one molecular species over the migration rate of others. In column chromatography the sample is transported by a carrier gas through a column packed with a material that aids separation. The rate of migration through the column for each component is different because of different retention time by the column. Ideally, each component emerges and is recorded separately—that is, at different times—as a peak of pure component mixed with carrier gas in the effluent gas from the column, Figure 1.

For a given application, the analytical determination is briefly and simply this: the retention or elution time—the time it takes for a peak to emerge after the injection of the sample into the column—identifies the component; the amplitude of the peak determines the amount of that component in the sample. In process chromatographs only the components important to operation are displayed.

The five major parts of the basic chromatographic system, Figure 2, are:

A—The column for separating the sample components

B—The carrier gas for transporting the sample through the column

C—The sample introduction unit (valve)

D—The detection device

E—The recording or display equipment

P—The programmer, not shown, that time-sequences the operation of the entire analyzer system.

Here is how such a basic chromatograph works: Carrier gas flows continuously at a fixed rate (say 60 milliliters per min) through orifice *O*-2, column

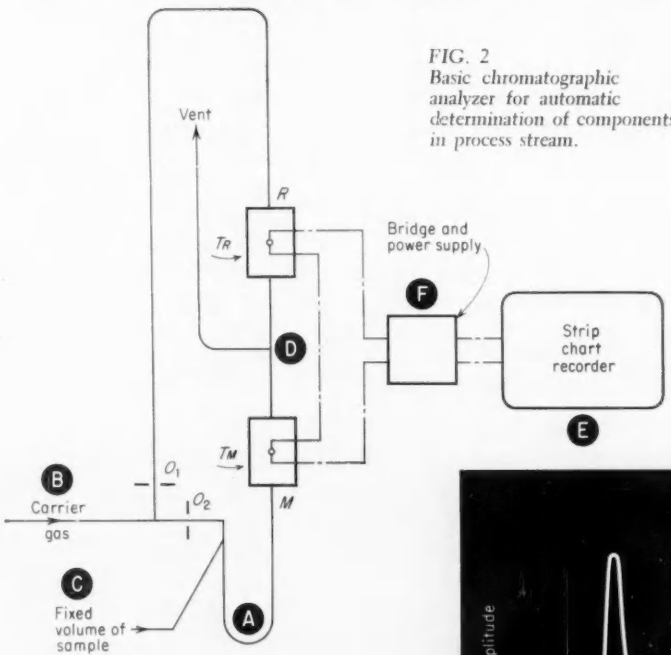
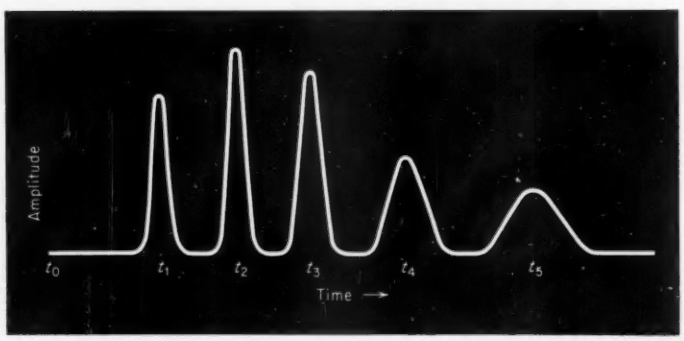


FIG. 2
Basic chromatographic analyzer for automatic determination of components in process stream.

FIG. 1.
Typical chromatogram shows how five components in stream are separated in time.



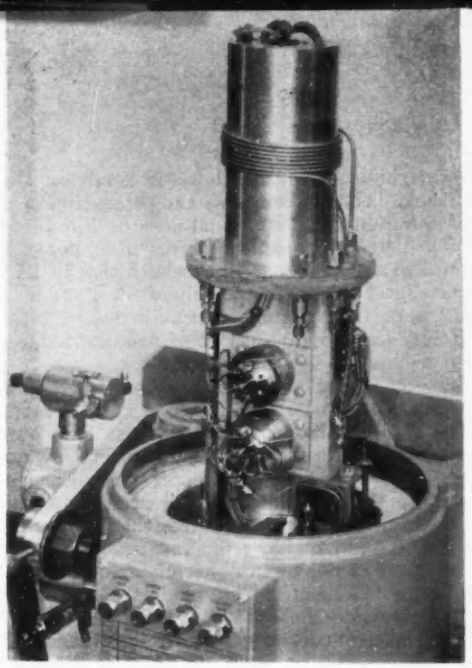


FIG. 3. Consolidated Electrodynamic's analyzer section uses helical column.



FIG. 4. Foxboro's analyzer column is made up of two crescents like that above with 15 individual U-tubes in each crescent.

A, and measuring cell M; a side stream of carrier gas flows through O-1 and reference cell R. Bridge F is balanced so recorder E reads zero. A fixed volume (1 ml) of sample is injected at time t_0. The sample components separate, peaking as they pass through and out the column. The first component emerges at t_1, is detected by measuring cell M, and is recorded as a peak on the recorder. Subsequent components emerge in order of their retention times, t_2, t_3, etc., as shown in Figure 1.

The chromatographic column

The column is usually constructed of ¼-in. o.d. or ¼-in. i.d. tubing, which varies in length from a few inches to over 100 ft and is packed with a solid material. The column is then shaped to fit the configuration of the temperature-controlled chamber in the analyzer; short columns are bent into U-shapes, longer columns into flat or cylindrical helices. Most analyzers employ helical columns, like Consolidated Electrodynamics Corp.'s process chromatograph, Figure 3. However, some use a different column design altogether—for instance, The Foxboro Company chromatograph uses a series of short U-tubes, Figure 4.

Columns are either packed or capillary. Capillary columns have not yet been used for in-plant chromatography. Packed columns can be divided into two types—adsorption and partition.

Adsorption columns use a fine-mesh solid material as a medium for selective adsorption of the various components present in the mixture to be separated. Separations are effected on the basis of the differences in strength of the adsorption bonds. Such columns should last indefinitely unless contaminated during operation. Typical adsorption materials are activated charcoal, silica gel, molecular sieves, and activated alumina. They separate N_2 and O_2, oxides of nitrogen, and the lighter hydrocarbons. The retention times for C_4 and heavier hydrocarbons on adsorption columns are too long and result in poor separation and resolution of peaks. However, partition columns can carry out these separations.

Partition columns use a relatively inert, solid, granular substrate material coated with a high-boiling liquid called the partitioning liquid. The liquid partitioning agent on the surface of the solid support provides great separating efficiency. Practical partition agents for plant-stream chromatographs should have the following properties: liquid coating must be chemically inert, have a low viscosity to coat the solid particles evenly, and have a vapor pressure of less than 0.1 mm Hg at the operating temperature of the column to avoid rapid depletion from the column.

Partitioning liquids can be divided into two types, polar and nonpolar. Nonpolar liquids such as paraffin wax, squalane, and vacuum grease separate components by their boiling point. They can, for example, separate ethane from propane, and ethane from ethylene. Some nonpolar partition columns have been operated at approximately 200 deg C. Polar liquids such as tri cresyl phosphate and dibutyl maleate separate components according to their chemical nature. Such liquids separate ethylene from ethane, olefins from paraffins, and polar from nonpolar materials. Most selective polar liquids are limited to about 125 deg C operation for long-term column stability.

Even under the best conditions the life of a partition column is limited. Every material has a finite vapor pressure and evaporates or escapes at a slow though finite rate. But by careful selection of coating materials makers can achieve column life of at least six months.

Detectors for chromatographs

The effluent from the chromatographic column is either pure carrier gas or a binary mixture of carrier gas and eluted sample component. A detector located adjacent to the column exit senses the difference in some physical property of the carrier gas

and the binary gas. The characteristics of the effluent set the requirements for the detector.

The binary mixture has a very small concentration and appears for a very short time. For example, suppose a 1.5 cc sample contains 2 percent ethane. The total ethane sample is therefore 0.03 cc. If the elution time of ethane is 30 sec, then the peak reaches its maximum 30 sec after sample injection. For a carrier gas flow rate of 60 cc per min, the base width of the ethane peak is (assuming no diffusion)

sample size/carrier flowrate =

1.5 cc/60cc per min = 0.025 min = 1.5 sec

The smallness of the concentration and its short duration peak (with normal diffusion, about 10-15 sec) indicates the need for sensitive, fast detectors and recorders.

The physical property most widely used for detection in plant chromatographs is differential thermal conductivity. Detectors based on this principle appear to be the most practical in over-all cost, sensitivity, stability, signal amplitude, and speed of response to concentration changes. The differential thermal conductivity measurement responds to the difference between the thermal conductivity of the carrier gas alone and the thermal conductivity of the eluted binary mixture of carrier plus sample

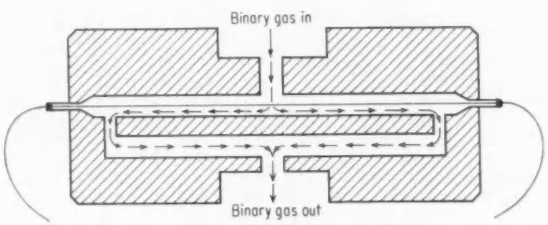


FIG. 5. Heated-filament thermal conductivity detector element. Foxboro design.

component. Thermal conductivity detector cells use either resistance-wire or thermistor elements.

In the resistance-wire thermal conductivity detector, four matched electrically heated filaments form a Wheatstone bridge. In Figure 2, for example, measuring section *M* contains two filaments and reference section *R* contains the other two filaments. Electrical bridge balance is attained with carrier gas only flowing through both sections of the detector cell. As the peaks elute into the measuring section, the heat lost by the filaments through thermal conductivity depends on the composition of the binary gas flowing past the measuring filaments.

The measuring-section filaments, sensible to this heat loss, change their resistance proportionally, while the filaments in the reference section remain at constant resistance. Thus the Wheatstone bridge develops an unbalance signal related to the difference in thermal conductivities between the gases in the two cells. Care must be taken that the temperature of heated filaments is not so high that it causes either reactions between sample components or hydrocarbon cracking.

Construction of heated-filament detectors obviously differs from maker to maker. Figure 5 shows the cartridge element developed by Foxboro. One or two such elements comprise the measuring section, depending on application and design. For this particular detector, Foxboro claims a 99-percent response to a step-change in concentration in 1.1 sec; a noise level of less than 2.5 microvolts; and a sensitivity such that a sample concentration of 2×10^{-5} micrograms of butane per cc of helium produces an output signal twice the noise level.

A second type of thermal conductivity detector employs bead thermistors, again in a bridge arrangement, as the heat-sensible elements. The over-all operation is quite similar to the filament type, except that thermistors have a large negative coefficient of resistance. Thermistor detectors are more sensitive at lower operating temperatures than filaments but less sensitive at higher temperatures. Generally operating life is shorter for thermistor detectors than for heated filaments. The small size of the thermistor beads does offer fast response.

The choice of carrier gas determines the detector's order of sensitivity, since the greater the thermal conductivity difference between the carrier gas and the component-carrying binary mixture the greater the bridge output. Hydrogen and helium, the gases offering the largest thermal conductivity difference, therefore contribute the most to detector sensitivity —a feature that far outweighs the fact that they contribute the least to component resolution.

Other detector types for in-plant chromatographs enjoy limited use now in those special applications for which t-c detectors are not suited.

Flame ionization detectors sense changes in the electrical conductivity of a hydrogen-and-oxygen burning flame when components of a hydrocarbon sample elute from the column. Beckman has installed several process chromatographs using flame ionization detectors. Beckman claims that through carefully controlled design, the same detector can be used for measurements of 5 to 10 ppm up to 10 percent full scale with good linearity. Perkin-Elmer and Mine Safety Appliances plan to introduce a flame ionization detector in the near future.

Radioactive gas ionization detectors employ a tritium or strontium-90 source and an argon-gas carrier. The beta radiation excites argon gas to its metastable state. With an applied potential of 1,000 to 3,000 volts between anode and cathode the excited argon gas does not ionize, and essentially no current is produced by the carrier gas alone. But when an ionizable substance, the eluted component, enters the detector then collisions between the sample and the excited argon atoms produce ions. The applied potential accelerates the ions to the cathode, producing a current proportional to concentration. Since the sample size and the applied voltage are adjustable, this type of detector permits a wide range of sensitivities.

Catalytic combustion detectors use platinum filaments whose resistances change when oxidizing or combusting of flammable samples changes filament temperature as a function of concentration. Air serves as the carrier gas for measurement of combustibles, and hydrogen for small concentrations of oxygen. This type of detector is more sensitive than thermal conductivity detectors for the lighter

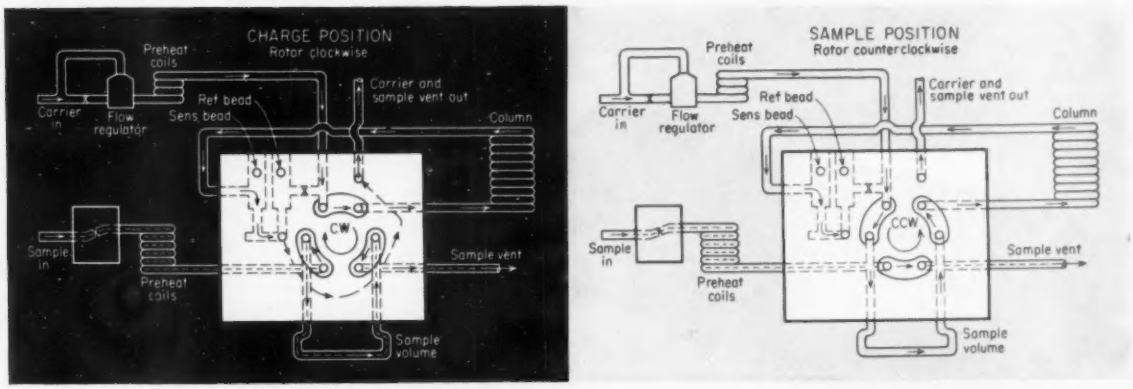


FIG. 6. Six-port sampling valve operation. Perkin-Elmer configuration.

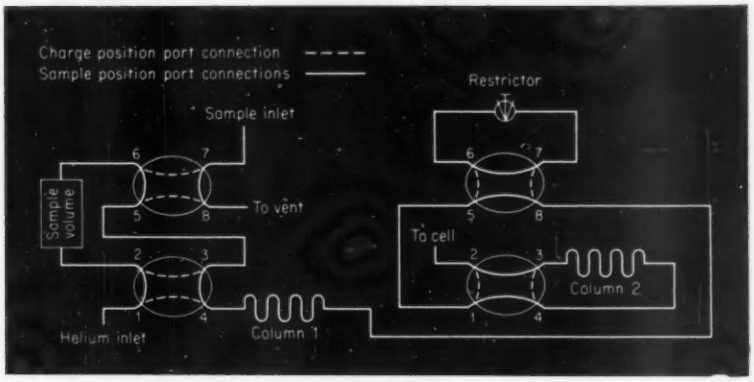


FIG. 7. Two eight-port valves in column switching arrangement. Mine Safety Appliances configuration in which both valves are positioned by a Geneva movement driven by an electric motor.

hydrocarbons. Greenbrier employs catalytic combustion detectors in some applications where this provides a simpler solution than thermal conductivity detection, or where air carrier gas offers a considerable advantage.

Sample and column switching valves

To automatically analyze a continuous succession of gas samples, a valve must trap a fixed volume of sample, connect it to the column, admit carrier gas to the trapped volume of sample and force it into the column, allow the carrier gas to flow until all of the measured sample has eluted through the detector, keep a fresh sample always flowing through the analyzer, keep the carrier gas flowing until the pen returns to the baseline, and momentarily stop sample flow so that a fixed sample volume is trapped again for the next programmed analysis.

The preceding steps can be carried out with a two-way six-port sampling valve, Figure 6. When the valve is in the *charge* position the sample flows through the sample volume and out the sample vent while the carrier flows directly into the column. When the programmer rotates the valve to the *sample* position the carrier sweeps the sample volume into the column. After separation, the components emerge from the column, enter the detector, and pass through the carrier-and-sample vent.

Multiple columns in which components are backflushed or stored temporarily are often used to give faster analyses of key components in the sample stream, improve resolution of total sample analysis, augment samples for favorable trace analysis, and protect columns from exposure to damaging stream components. The reference describes in considerable detail the benefits and variations of multiple-column chromatography.

The key problem here is that multiple-column chromatographs must have a column selector valve interposed between columns to effect column backflushing and sample storing. Figure 7 shows a two-column arrangement using two independently rotated two-way, eight-port valves. Most analyzer makers operate their sample and column switching valves independently. Perkin-Elmer, however, prefers to use one valve for both operations, with 6, 8, or 16 ports as needed for the application.

One recent innovation in industrial chromatographs is a valve that can inject a liquid sample as small as one microliter directly into the column. Because carrier dilution vaporizes the sample inside the column, liquid sampling eliminates the need for a vaporizer in the sample handling system. Furthermore, liquid sample injection permits the analysis of materials having boiling points even higher than the analyzer's operating temperature. Then too, because a given material can be analyzed at lower temperatures there is less tendency for the material to polymerize and degrade the column.

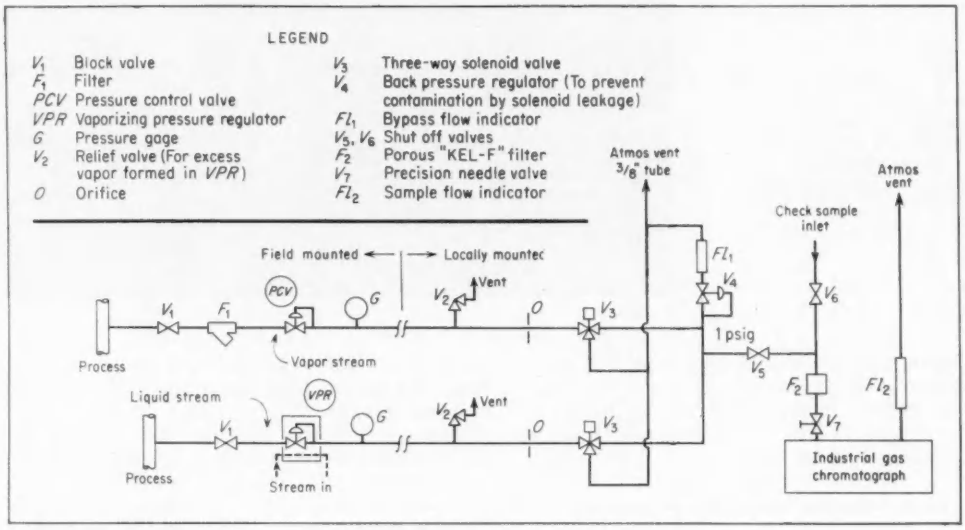
Sample handling

Complex piping arrangements and accessories are often needed to inject a clean, representative sample of the process stream into the analyzer. The ramifications of sample handling are numerous. Whether the process stream is a liquid or a gas, the sample must be filtered. Sometimes the sample lines must be steam traced to prevent sample condensation. Often a liquid sample must be vaporized before en-



FIG. 8. Pressure vaporizing regulator provides a regulated vapor flow from liquid sample stream. Greenbrier manufacture, under license from Phillips Petroleum Co.

FIG. 9. General sample handling system. Beckman.



tering the chromatograph, Figure 8. Sample lines must not leak. All these requirements, and many others, are compounded when the same chromatograph analyzes several different streams in sequence, for then piping, manifolding, and line switching becomes more complicated. Figure 9 typifies the arrangement and accessories needed for sample handling of liquid and gas streams.

The importance of filtering cannot be overestimated. Filters for removing water, oil, and dirt from the sample and carrier gases must be inserted in the piping from the sample-takeoff point to the entrance to the column. Such filters usually come with the chromatograph but specific plant processes and conditions may require more filters than ordinarily provided. Contaminants entering the stream either with the carrier gas or with the sample from the process stream quickly render the column useless. They deposit on the packing material, decrease the effective area of separation, and shift the retention times from their initial calibrations, thus reducing the ability of the column to separate the sample components. The retention-time calibration shift is particularly detrimental since process chromatographs operate with a programmed time schedule as required for automatic analysis and control of plant streams.

Displaying the analysis

While component percent-by-volume concentration measurement truly depends on peak area, the practical alternative for in-plant chromatographs is to measure peak height. The analyzer is calibrated with a standard mixture and the peak height of each component curve is related to its corresponding gas concentration in the known mixture. For the peak-height method to work in plant chromatographs, the volume of the injected sample must be the same for all repetitive analyses; the carrier gas flow must be maintained constant within plus or minus 0.1 percent; the carrier gas, the injected sample, and the detector must be maintained at a constant temperature, for example, at 50 deg C plus or minus 0.1 deg C; the column length, diameter, and packing material must be such than each component separates symmetrically; and the detector must not drift and must be linear.

To carry out automatic readout usually requires several variable signal attenuators in the detector circuitry—since equal volumes of different gases (components) produce vastly different output signals. A programmer connects each attenuator to the detector circuit when the time arrives for a particular peak to be recorded. Thus, the recorder's

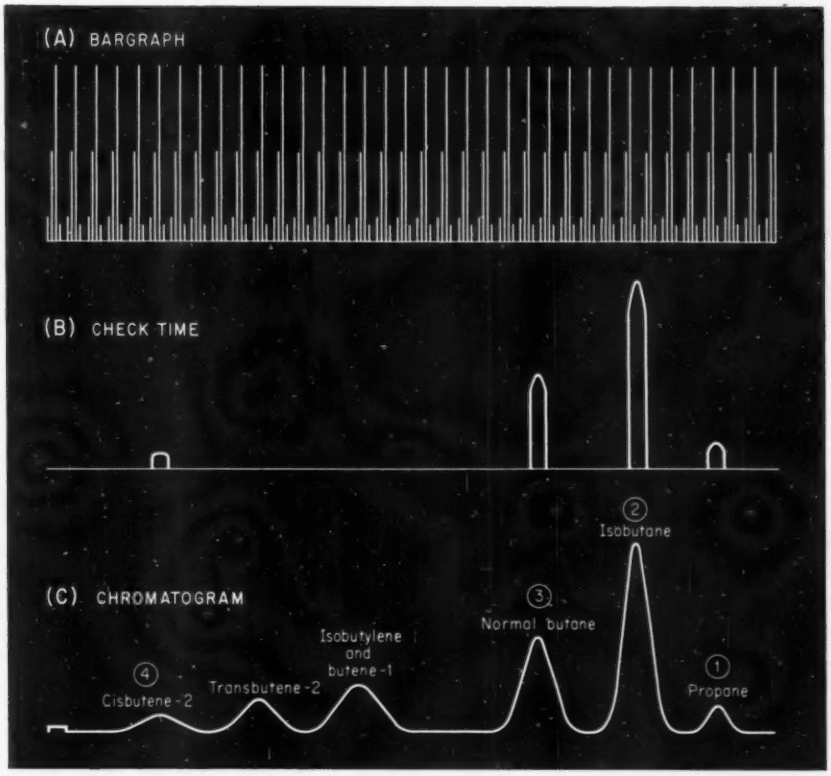


FIG. 10. Three usual methods of recording chromatograph output: bargraph, check time, and chromatogram. In the bargraph (A) the peak height of the four numbered components in full chromatogram (C) are recorded. Note that about 35 analysis cycles can be displayed as bargraphs on the same amount of chart paper required for one chromatogram, a feature that not only saves recorder paper but facilitates process trend observations.

full deflection is made available for each range of component concentration.

The peak-height method applied to plant stream analyzers has led to the so-called bargraph record, in Figure 10A. For each peak the programmer advances the recorder chart about ¼ in., stops the chart, and gates the detector circuitry long enough for the recorder pen to reach full peak height. Usually a double space separates the last peak of one sample from the first peak of the following sample.

For calibration and startup purposes, most analyzers also permit check timing, Figure 10B, and chromatogram presentation, Figure 10C. Check timing is the same as bargraph presentation except that the chart is allowed to run continuously, although gating permits a record only near the peak. This mode is particularly advantageous in checking and setting the programmer to the correct gating intervals and retention times for each peak of interest in the analysis. In the chromatogram presentation, the chart paper also moves continuously.

Often the operator wants trend information on the change in concentration for each component. The bargraph, Figure 10A, does offer trend information when the operator visually compares the height of one component in a sample with the corresponding height of the same component in preceding and

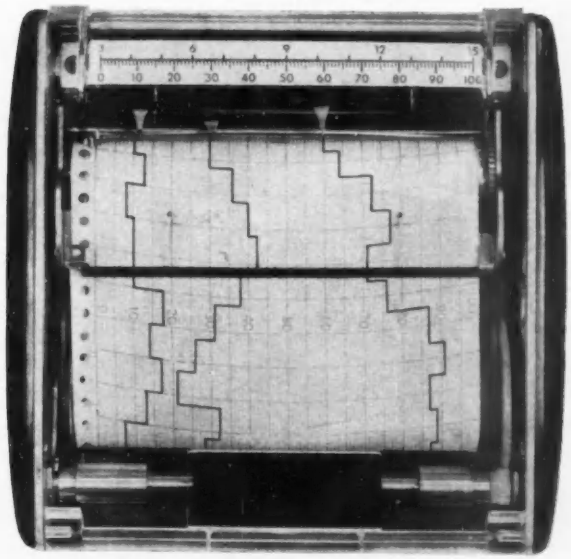


FIG. 11. Three-pen recorder displays concentrations of three components. Foxboro.



FIG. 12. Digital readout for chromatographs. Beckman.

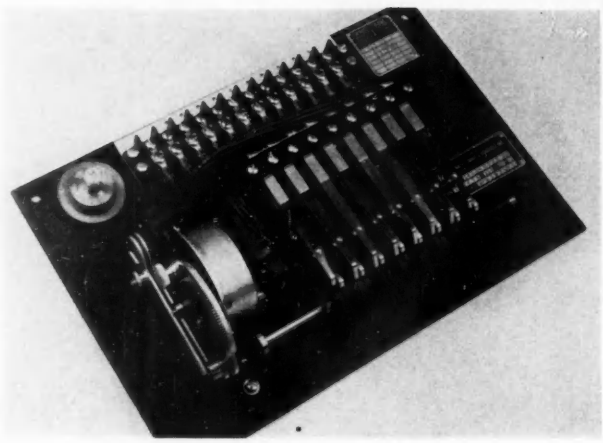


FIG. 13. Motor-driven multiple cams typify timing unit in many programmers. Automatic Timing and Controls, Inc.

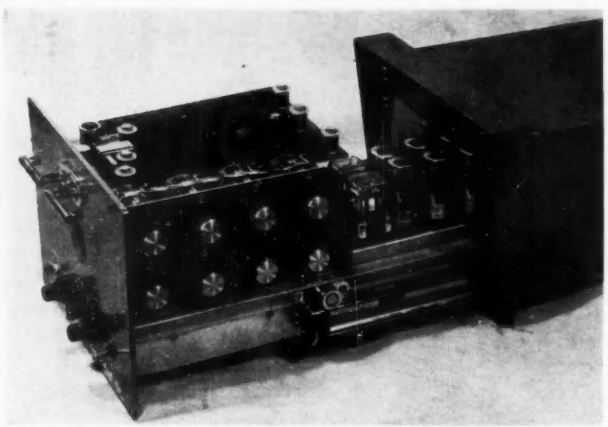


FIG. 14. Pencil-marked film tape sequences programmer functions. Mine Safety Appliances.

succeeding samples of the same stream. However, when the chromatograph and the recorder are analyzing and displaying several components in each of several different streams in sequence, it becomes more difficult for the operator to ascertain trends.

One way to simplify trend recording is to use a separate pen for each component. Figure 11 shows a three-pen recorder for trend recording of three components, with each trace written in a different color to further ease recognition of the components. This type of trend recorder requires a peak picker that senses and retains the peak height until the same component in the succeeding sample elutes.

Peak pickers are important for trend recording as above, for providing stored control signals related to concentration peak height, and for both functions simultaneously. Peak picking can be accomplished pneumatically, electronically, and electromechanically, the choice depending basically on the type of signal needed for indication and control.

The stored signal also acts as a stored-value measured variable for a control loop. Once the component concentration signal is developed, it can be operated on like any other measurement signal as suits the application. One stored peak height signal can serve as the primary measured variable in a cascade control loop; two stored peaks can be ratioed; and analog peaks can be fed into analog computer control systems or converted into binary electrical signals for entry into digital displays, Figure 12, and digital computer control systems.

Automatic programmers

The numerous time-based functions important to successful continuous operation of chromatographs in the plant are carried out automatically under the direction of a programmer. Among these functions are selection of detector circuit attenuator for each component, initiation and duration of the gating intervals for bargraph or check time display of each peak, selection of proper stream in multistream applications, automatic zeroing of detector circuitry (when pure carrier gas is being eluted) to compensate for detector drift, and sequencing of all phases of sample and column switching valves operation.

In simplest terms, programming action is obtained by tripping the proper switch at the proper instant for the necessary time duration. Once the switch is actuated the appropriate function such as automatic zero is carried out. In practice, however, programmer operation and equipment becomes more complex, particularly when the chromatograph is applied to determinations of concentrations of several components in several different streams.

Some manufacturers use several cams driven by the same motor to actuate and deactuate switches in time sequence, Figure 13. Other makers use a long motor driven tape or belt. Mine Safety Appliances, for instance, employs a 16-mm translucent film tape in its programmer, Figure 14, on which vertical pencil marks are placed at times corresponding to the start and stop of each function. Light-interruption signals from the tape in turn sequence a stepping switch whose contacts apply power to relays, solenoid valves, and sample injection valves.

WHO MAKES PROCESS CHROMATOGRAPHS

Six instrument companies manufacture process chromatographs for in-plant applications. They are Mine Safety Appliances, Beckman, Greenbrier, Consolidated Electrodynamics, Perkin-Elmer, and Foxboro. (Leeds & Northrup have sold several chromatographs and are continuing product development.) The chromatographic equipment described in the following pages contain many features, some unique to a particular analyzer and some common to several. A lack of mention is not to be construed as an implication that the chromatograph offered by a company does not have that feature.

THE PERKIN-ELMER CORPORATION

The Perkin-Elmer Corp., Norwalk, Connecticut, makes two basic chromatographs, the standard Model 184 series and the newer, less complex single-component Model 284 series.

The sensing unit (analyzer section) in Perkin-Elmer's 184 instruments uses an electric motor actuated rotary valve with 6, 8, or 16 ports depending on the application. The six-port valve only introduces sample into the column. The eight-port valve performs both sample introduction and backflushing, the backflushed components passing through the detector where they are measured as a single component. The 16-port valve performs sample introduction, backflushing, and multicolumn operations without column storing. The valve handles gas-sample sizes from ¼ cc to 20 cc.

Perkin-Elmer uses only thermistor beads in its thermal conductivity detector. Aside from giving good long-term stability, the maker claims, thermistor elements provide the highest change in resistance per change in temperature due to changes in effluent thermal conductivity. The company has developed a flame ionization detector for its process chromatographs which it is now marketing.

The sensing unit temperature is controlled by on-off electronics to within 0.2 deg C. To eliminate sample condensation, steam tracing of lines and accessories is provided both internally and externally to the analyzer. Figure 15 shows P-E's heated sample flowmeter assembly.

The programmer, Figure 16, uses cam actuated mercury switches, and magnetic leaf switches actuated by preset tabs on the front timer dial to start the gating of each of four components. The gate width is easily adjustable. A distinctive feature of the programmer is that it meets the requirements of Class I, Group D, Division 2 installations without air purging.

Stream switching is accomplished by an auxiliary cam assembly integrally tied to the programming timing motor, assuring that stream selection and range changing never go out of synchronism.

Perkin-Elmer chromatographs permit a choice of bargraph, chromatogram, and check timing display, as shown in Figure 10. For those applications needing trend recording or a control signal, the peak picking recorder is used. This recorder is a potentiometric emf-to-air transducer/recorder modified to retain the three usual display functions and at the same time pick one or more stream components and continuously transmit a 3 to 15 psi signal proportional to their peak heights. Thus, the company provides as part of its system a 3 to 15 psi signal (or an equivalent electronic signal) to controllers of standard manufacture.

The Model 284 high speed chromatograph is available in a choice of two different programmers. A basic, single-component programmer is suited for those control and monitoring applications where the continuous transmission of only one component is required. A multicomponent programmer, for transmission of one or more components, offers bargraph recording as an optional feature. Perkin-Elmer also makes a liquid sampling valve for use in its 284 chromatograph, as well as such control devices as ratio computers that provide signals related to one or more summed-components peak areas.

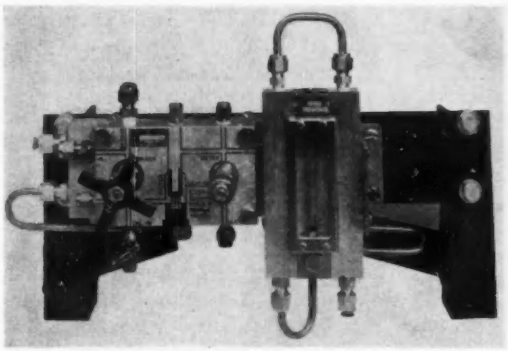
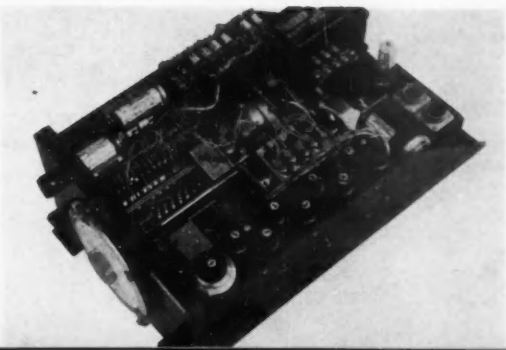


FIG. 15. Heated flowmeter assembly is part of Perkin-Elmer's line of accessory equipment for sample handling.

FIG. 16. Chassis is for a two-range, four-component programmer. Front panel is from a four-component programmer handling six streams of similar composition. Perkin-Elmer.



GREENBRIER INSTRUMENTS COMPANY

Greenbrier Instruments Co., Ronceverte, West Virginia, makes one of the most complete lines of chromatographic analyzers. Its CHROMA-MATIC series consists of several analyzer sections and several control and programmer sections for a variety of applications.

Analyzer design is based on the approach developed by Union Carbide Olefins Co. The temperature stabilized section is an insulated sheet-metal box, with temperature control obtained by circulating heated air. Two air streams, one heated, the other not heated, join within the temperature stabilized zone, with a thermostat proportioning the amount of heated and unheated air circulating in the zone.

The metal-box configuration permits adequate space for multiples of columns, switching valves, sampling valves, and detectors.

Greenbrier offers a standard analyzer, Figure 17, for percent determinations for use up to 125 deg C; a high-sensitivity analyzer for 50 to 100 parts per million full scale determinations; a high-temperature analyzer for the 125 to 200 deg C range; a dual-temperature analyzer, permitting part of the determination to be conducted at one temperature and the remainder at another; and a dome-type analyzer with a simple on-off heater, which has little versatility but is good for simple, routine analysis.

The basic control section suits standard applications of one stream with up to four components of interest. Its panel contains a visual indication of all functions. Automatic programming is accomplished by a cam type timer that actuates microswitches. Manual controls enable the operator to program the entire analysis. A simple stream selector connected to the control unit sequences different streams, which are all subjected to the same analysis, to the analyzer.

For more complex applications Greenbrier uses a modular programmer, Figure 18, consisting of separate power supply, attenuator-timer, stream selector, and memory and readout modules. An additional module serves for those analyses where a number of components are wanted in various ranges in streams having differing compositions. This program module contains a matrix board with calibrating potentiometers (one for each component-and-attenuation combination) on one coordinate and sampled streams on the other coordinate. Thus, for each stream the operator can select the components to be measured and their range by plugging diodes into the intersection of the appropriate coordinates on the matrix board. As a minimum, the modular programmer requires a power supply and an attenuator-timer, the combination handling one stream of up to eight components of interest.

Greenbrier's basic sampling valve is an 8-port linear motion valve using *O*-ring seals and actuated by air pressure. The length and internal diameter of a loop of tubing determines sample size (minimum: 0.25 cc, maximum: virtually unlimited). The flow of carrier gas flushes the sample into the column. The same linear sampling valve with different connections serves for backflushing and multiple column operation. Greenbrier also has a plunger valve, Figure 19, especially suited for injecting liquid samples as small as one microliter and up to 20 microliters. A size-controlling cavity in the plunger traps a measured quantity of sample that is transferred bodily into the carrier gas flow.

For display and control, Greenbrier can supply full chromatogram, standard bargraph, bargraph with stream identification for multiple stream analysis, and check timing. In addition the company has installed printing trend recorders, and digital printout. The company also manufactures an electronic peak picker, an electronic peak picker and memory, an electrical memory in which potentiometers are driven to the peak value and locked, and pneumatic memory systems.

Most chromatographs sold by Greenbrier are application-engineered, with the maker supplying the columns and with the instrument warranted to perform a specific measurement. As an aid to customers, Greenbrier offers predelivery training in its engineering laboratory at no charge, and postdelivery training at the purchaser's plant at a standard charge per day for the engineer's services.

FIG. 17. Greenbrier's chromatograph for component determinations in the percent range.

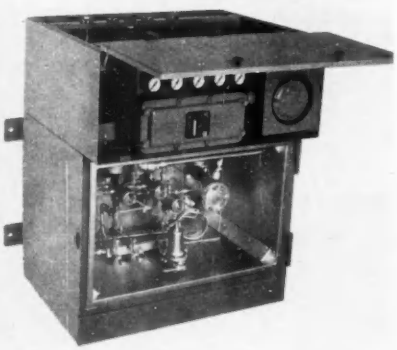
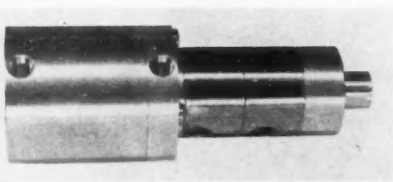


FIG. 19. Plunger valve for injecting liquid samples directly into the column.



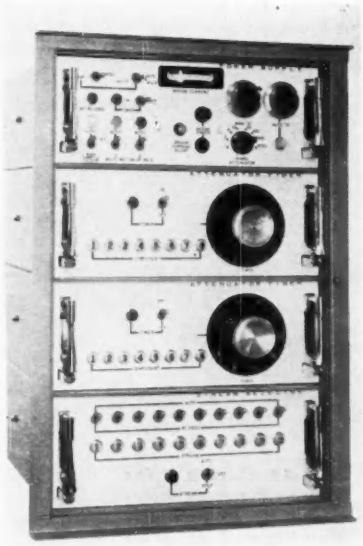


FIG. 18. Greenbrier's modular programmer.

THE FOXBORO COMPANY

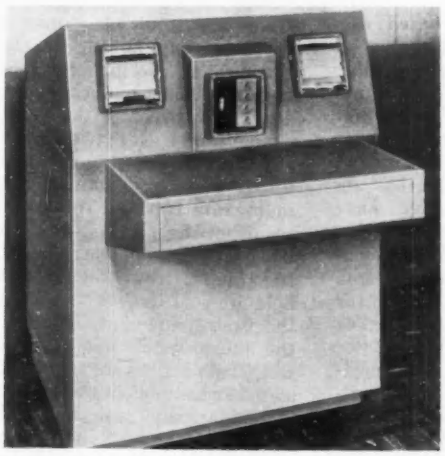
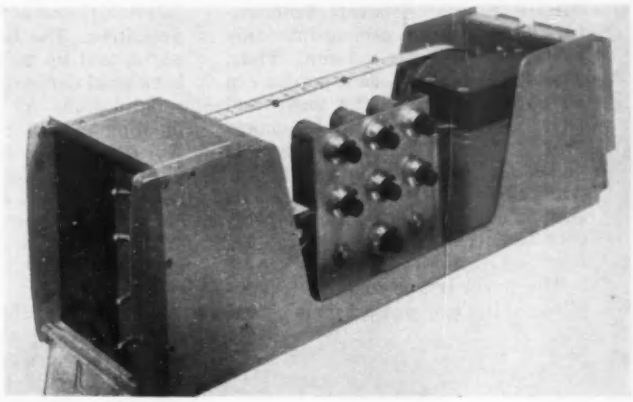


FIG. 20. Console mounts two three-pen recorders and one programmer.



FIG. 21. The Foxboro programmer uses a rotating metal belt to initiate all programmed functions in the chromatograph system.



The Foxboro Company, Foxboro, Massachusetts, has been developing a chromatograph for seven years. Experience gained from field tests on early prototypes has led to the design of a new unit that is now being given final evaluation tests at Foxboro and field tests. The display and programmer sections are shown in Figure 20. Present schedules indicate that a limited number of production units will be available for sale in the fall of 1961.

The Foxboro analyzer section of the chromatographic system contains all functional components (columns, sample valve, detector, and column switching valve) in one temperature controlled section. During laboratory tests to determine the effect of ambient temperature on the internal analyzer temperature, results showed, for example, that an external change between 30 deg F and 120 deg F over a 4-hour span caused the internal temperature to vary less than 0.05 deg. F. A second section contains such equipment as flow controls, heating controls, filter, and auxiliary equipment. The analyzer, for in-plant operation, is designed for Class I, Group D, Division 1.

This chromatograph employs either a gas sampling valve or a liquid sampling valve, depending on the application. Both valves use a sliding annulus that determines sample size as small as one microliter. Positive spring loading of slide components has given leakproof operation up to 100 psi. The valves are air-actuated.

As shown in Figure 4, Foxboro's column is crescent shaped, rather than the conventional helix. It is made of $\frac{1}{8}$-in. i.d. 316 stainless steel using Teflon seats for positive sealing. Each crescent (two per analyzer) contains 15 *U*-tubes, each from 3 to 16 in. long, connected in series with Teflon-seated jumpers. The jumpers can be positioned in the field to allow a choice of column length up to 40 ft. The individual *U*-tubes make the column easy to pack and to clean and repack.

The thermal conductivity detector for this chromatograph contains in its measuring section one or two heated-wire filaments like that shown in Figure 5. The detector bridge is energized from a 1,000 cps constant voltage supply, and is used in conjunction with Foxboro's Resistance Dynalog as modified for chromatography. The arrangement permits the readout to be at least 1,000 feet from the analyzer. Another detector, based on argon radioactive ionization, can measure 1 ppm with a sample size of 200 microliters. It has a base-line stability of less than 2 percent drift in 24 hours.

Foxboro's programmer, Figure 21, is designed for Class I, Group D, Div. 2 installations. Its operation is based on a 38-in. long metal belt that makes one rotation for each analysis. Timing actuators fastened to the belt trip small switches that in turn actuate stepping switches. The metal belt is numbered to indicate analysis sequence and to position actuators on initial startup.

The programmer handles six components that are displayed on two three-pen recorders, see Figure 11. During normal process operation all traces will be for trend recording based on peak height, but by a switch on the front panel the operator can call for a full chromatogram as traced by one pen. The programmer also provides for introducing a standard sample for calibrating the analyzer. Like other programmers, this one provides automatic attenuation for each component and automatic zeroing at the start of each analysis cycle.

For closed-loop control, the pneumatic receiver used with the chromatograph, Foxboro type M/54, is designed to have a standard pneumatic controller (type M/58) mounted integrally at the rear. Each three-pen receiver puts out a 3 to 15 psi signal for each of three component peaks. The company can supply control stations for adding and subtracting, for multiplying and dividing, and for cascading —these stations obtain their inputs from the receiver signals.

CONSOLIDATED ELECTRODYNAMICS CORPORATION

Consolidated Electrodynamics Corp., Analytical and Control Instrument Div., Pasadena, California, was one of the first companies to offer an in-plant process chromatograph. The CEC analyzer unit, Figure 22, has separate temperature zones for the sample introduction valve and the column. Thus, samples with high dew points can be run by keeping the valve and surrounding area at a high temperature. Then, after the sample is picked up by the carrier gas its dew point drops and the column can be run at a lower, optimum temperature (or higher vapor pressure) for best separation.

The ports in the analyzer's sampling valve are opened and closed by a pneumatically actuated diaphragm. As a result, the valve introduces small samples reproducibly as a slug to the head of the column without any diffusion by the carrier gas. The valve operates at up to 150 deg C and at high column head pressures. The basic valve has six ports, and up to three valves have been used per instrument to achieve combinations of precutting, backflushing, and dual column operation. Normal sample size is 0.1 milliliter gas volume, but smaller samples permit high resolution and larger ones high sensitivity. A liquid-sample injection valve is also available for applications requiring its advantages.

For good stability and trouble free operation, CEC prefers filament type thermal conductivity detectors, but for higher sensitivity and faster response they sometimes use thermistor detectors.

The programmer, Figure 23, in the Consolidated chromatograph handles up to nine separate components. It permits bargraph or chromatogram presentation, (where needed) stream selection with automatic sequencing of up to eight streams or repeat runs on any of up to eight streams with proper attenuation for each component, permanent stream identification on the chart, and assorted lights and indicators to display valve actuation and other functions. The basic timer uses multiple cams, with individual cams sliding on the shaft through a friction clutch so that they can be set by locking the timer shaft and rotating the cam to the proper angle. Gate widths are easily adjustable. The programmer is set up by making a manual full chromatogram run and rotating on the recorder the percent of cycle time when each component elutes. Then the timer is revolved manually and held in position while the cam for the first component is turned until the microswitch arm falls into a slot. This procedure is repeated for all other components to be recorded.

Besides bargraph and full-peak presentation, CEC also provides various trend readouts: a peak picker and storage unit that transfer these peaks to different pens of a multiple pen recorder, or to a multipoint print wheel recorder, or to a segmental chart recorder.

Installations of CEC chromatographs include a number of pneumatic and electronic devices such as peak summers. Two examples show why the chromatograph is a versatile process control tool: In alkylation plants, C_4 olefins have been measured and totaled and their ratio to isobutane computed. In a sulfur recovery plant tail gas stream, the ratio of hydrogen sulfide to sulfur dioxide has been computed and used to monitor and operate the process.



FIG. 22. Consolidated Electrodynamics Corp. analyzer fits in domes suited to field installation in hazardous areas.

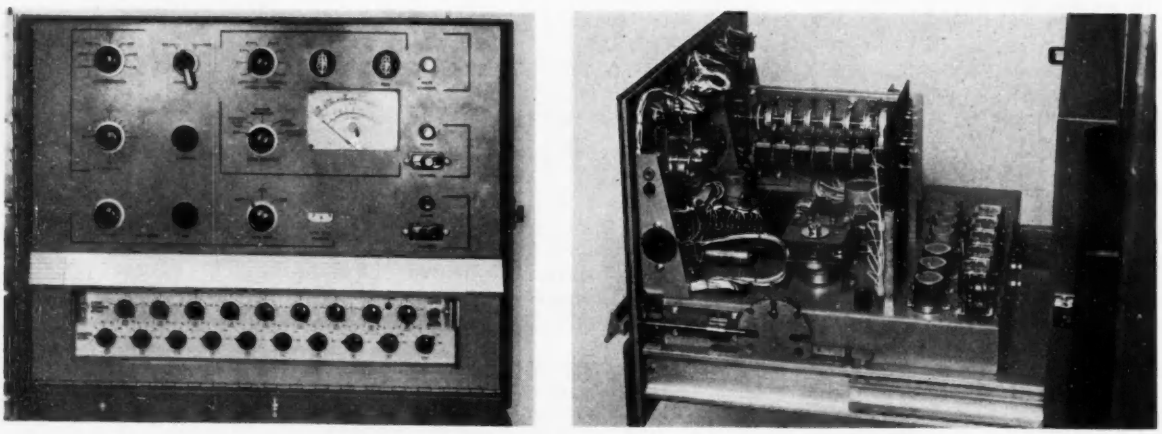


FIG. 23. CEC programmer handles up to nine separate components. All adjustments and such information as the stream and peak being measured at any given moment are available on the front of the programmer.

BECKMAN INSTRUMENTS, INC.

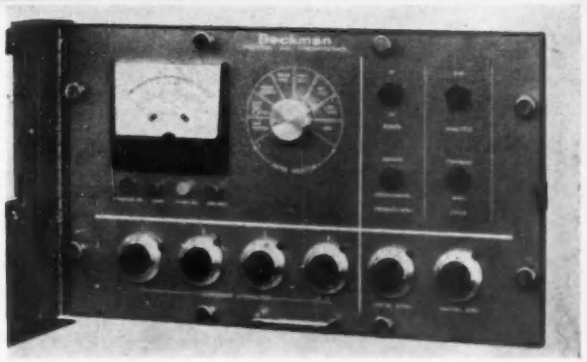
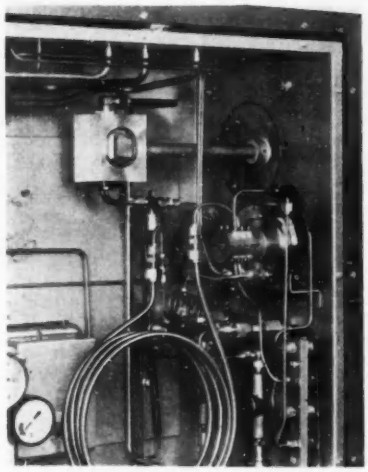


FIG. 24. Beckman Model 320 control unit sequences chromatograph functions to analyze one stream having up to six components.

FIG. 25. Beckman's analyzer section uses sliding plate valve for sample injection and either a thermal conductivity or a flame ionization detector.



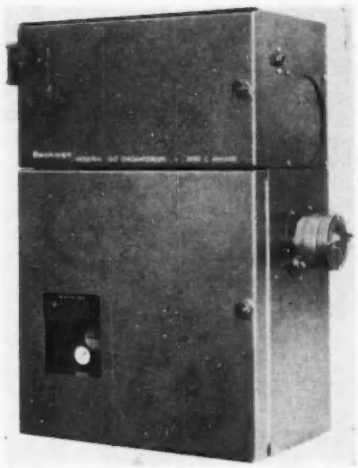
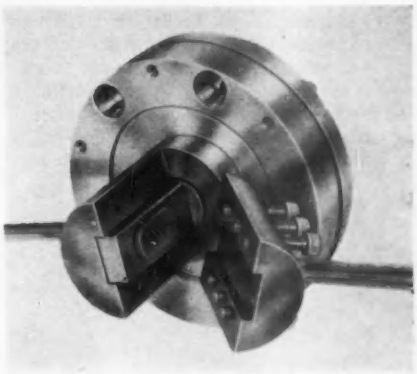


FIG. 26. Liquid sampling valve opened to show sliding plate whose holes determine sample size.



Beckman Scientific and Process Instruments Div., Fullerton, California, recently introduced its Model 320, Figure 24, (a replacement for its previous Model 120) for analyzing one stream with up to six components of interest. In conjunction with Beckman's automatic stream selector, this chromatograph may be used to monitor several identical streams. The Model 220 handles up to three nonidentical streams.

The Beckman programmer uses a commercial timer driving cams that in turn operate snap acting positive contact switches for its programming functions. Among the several functions this programmer carries out, like those of other makers, is automatic zeroing. Once each cycle, when only carrier gas passes through the detector, the detector output signal is sent to the recorder balancing system. If any detector output exists, as from drift, the recorder amplifier output energizes a motor that drives an automatic-zero potentiometer in the proper direction to balance the detector.

This company's new Series C analyzer, Figure 25, employs thermal conductivity detectors or flame ionization detectors. This analyzer incorporates a linear sliding plate sample injection valve, Figure 26, that has 4, 6, 8, or 10 ports. Connections are made by small holes (that determine injected sample size) in the sliding member moving between two stationary members. The sliding valve, which can furnish samples smaller than one microliter with a repeatability better than ¼ percent, permits direct injection of a liquid sample to the column—a feature that allows operation of the complete analyzer at a temperature far below the dew point of the sample. The sliding valve has made possible the analysis of liquids having relatively high boiling points while operating the analyzer unit at temperatures as much as 100 deg C below the boiling points of these liquids. For example, it is possible to analyze gasoline samples for the light ends up to C_4's and some C_5's in less than 10 min while operating the analyzer at 70 deg C.

Beckman chromatographs function with several different types of detectors. The company makes heated-filament and thermistor thermal conductivity detectors and its new flame ionization detector. Application engineers recommend the best detector for the application: generally filament detectors for 1,000 ppm full scale or over, thermistor detectors for situations where high temperature or metallic surface (of heated wire filaments) would bring about thermal cracking or catalysis, and recently flame ionization detectors for measurements of 5 to 10 ppm full scale.

For display to the process operator, Beckman's chromatograph permits the usual full chromatogram, bargraph, and check time readouts. Optional readouts, supplied on a custom basis, include trend recording and digital outputs for display, computer inputs, and typewritten records. Several such systems have been installed. As a further option, the company will supply mechanical and electrical peak picking and one pneumatic and two electronic memory devices.

Beckman offers various approaches to process control through chromatography. They have, for example, supplied single-component and ratioed-component setpoint signals directly into cascade control loops using pneumatic proportional, reset, and rate action controllers that in turn adjust the manipulated process variable.

MINE SAFETY APPLIANCES COMPANY

Mine Safety Appliances Co. Instrument Div., Pittsburgh, Pa., makes its chromatograph in four sections: the analyzer unit, the dual zone temperature controller for the analyzer, the tape programmer, and a recording potentiometer.

The MSA analyzer unit, Figure 27, incorporates a rotary eight-port valve (two banks of four ports) for sample injection and uses additional valves as needed for multicolumn analyses. The valves are driven through a Geneva movement from an electric motor. This arrangement is adaptable to two separate sample volumes on the same valve—injecting a 1 cc sample for normal analysis and 10 cc for trace analysis in the same analysis cycle.

This company also prefers the helical column in its analyzer. The columns are made of 316 or 304 stainless steel, usually ¼-in. o.d., 0.020 wall, soft annealed for easy coiling and good fit around the temperature controlled heat sink mandrel. MSA packs the columns with both adsorption and partition materials as suits the application.

The thermal conductivity detector is housed in the analyzer's high temperature zone along with columns, sample and column switching valves, and carrier gas regulators. A second, low temperature zone surrounds the high temperature zone and aids in keeping internal components at a precise temperature.

The Mine Safety Appliances programmer, Figure 14, operates from a marked film tape. It offers the functions of peak selection, variable attenuation, detector zeroing, sequence readout, multistream sampling, recorder chart spacing, and valve actuation. The maker claims extreme accuracy of programming times (within 0.5 sec) with excellent repeatability (within 0.1 sec). As shown in Figure 28, the film tape is marked with a lead pencil to mark the start and end of each function. Although the figure includes only a few components, the standard programmer actually handles up to eight components on one stream.

MSA will furnish complete sampling systems that start at the customer's sample takeoff point on the process. The company guarantees these systems for one year from startup (except for normally expendable items such as electronic tubes and filter cartridges). MSA application engineers are also prepared to advise on or furnish specifications for sampling systems fabricated elsewhere. As with most chromatograph makers, Mine Safety Appliances Co. performs all application engineering and checks out its instruments prior to shipment. It will assist the customer during startup, since MSA has qualified field engineers located throughout the country. In addition, MSA supplies pre- and post-delivery training to customer engineers interested in its chromatograph.

FIG. 27. Mine Safety Appliances analyzer section has two temperature zones.



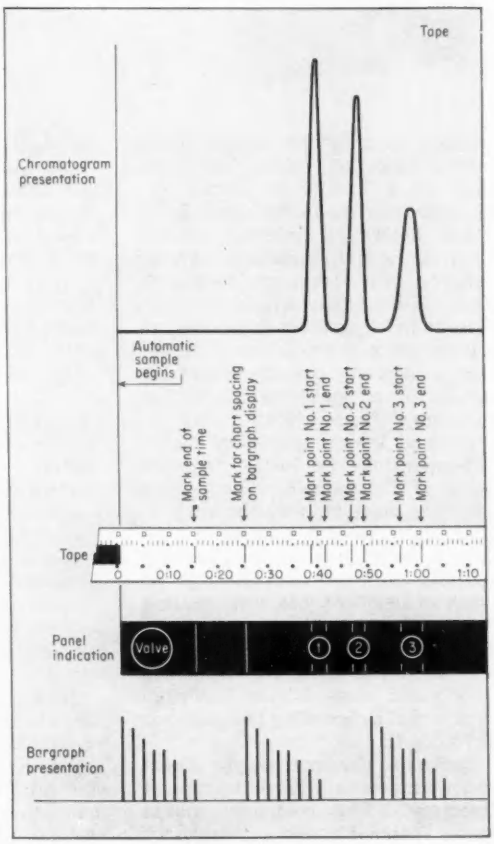


FIG. 28. MSA programmer is sequenced by pencil marks on film. Photoelectric pickup senses marks and initiates each function.

REFERENCE

MULTIPLE COLUMNS IN CHROMATOGRAPHY, W. J. Baker and T. L. Zinn, "Control Engineering", January 1961, pp. 77-81.

ACKNOWLEDGEMENT

The author appreciates the cooperation of the following persons: M. D. Weiss (Union Carbide Olefins Co.) who aided in outline preparation and gave independent review to the final manuscript; and W. Herkness (Greenbrier), W. S. Bierbaum (Beckman), H. J. Maier (Perkin-Elmer), E. E. Escher (Consolidated Electrodynamics), J. L. Mansfield (Foxboro), and C. Shartzer (Mine Safety Appliances) who supplied general information on chromatography and descriptions of the chromatographs and auxiliary equipment made by their companies.

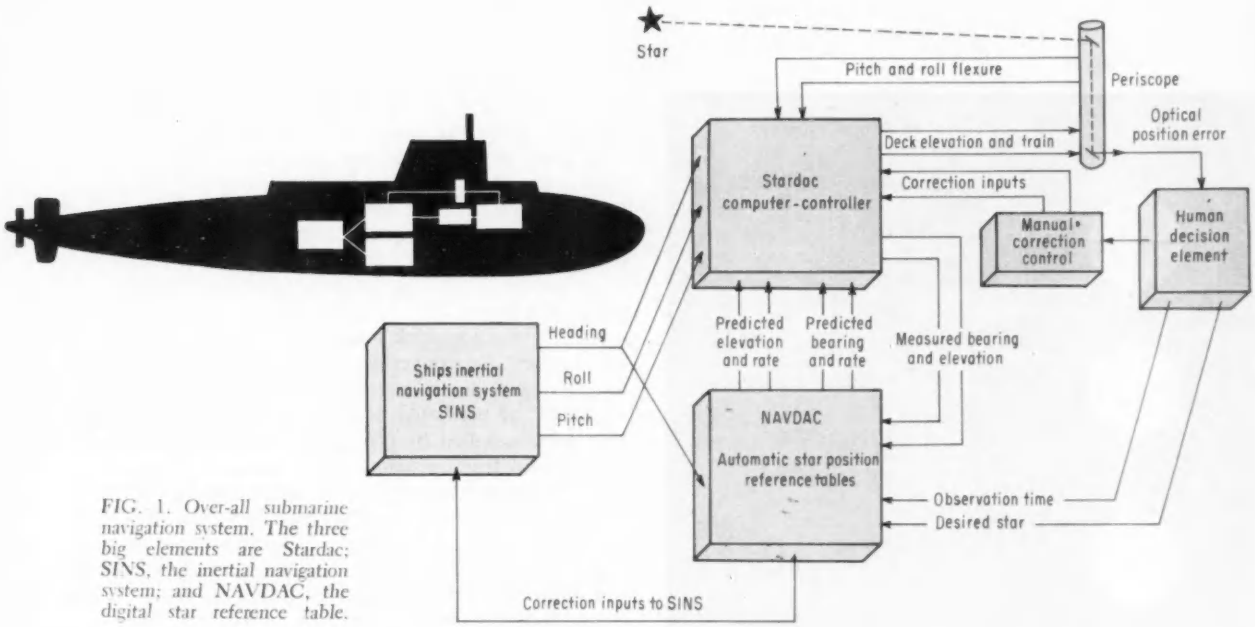


FIG. 1. Over-all submarine navigation system. The three big elements are Stardac; SINS, the inertial navigation system; and NAVDAC, the digital star reference table.

STARDAC: a hybrid computer keeps sub on target

GILBERT D. BEINHOCKER
THOMAS J. FITZGERALD
Epsco, Inc.

Because the gyros in the navigation system of a missile-firing submarine drift, the sub's skipper periodically tracks a star position with a special periscope to insure that he knows his position accurately. A unique special purpose computer helps calculate the correction necessary to offset drift and generates a control signal to stabilize the periscope during tracking. Stardac is a hybrid digital machine that uses both conventional binary arithmetic and incremental techniques.

For pinpoint accuracy on target the launching of a Polaris missile at sea demands a precise knowledge of the position and true bearing of the ship at the instant of firing. A missile-firing submarine carries a complex inertial navigation system—with gyro stabilized platforms, accelerometers, and digital computer—to determine the position of the launching point accurately. But the gyros in such a system drift, particularly over the long periods of a submarine patrol. To correct this damaging drift, the sub's navigator periodically fixes a star precisely through the periscope so that a special purpose computer system can calculate a correction for the gyros. Stardac, a hybrid computer, not only calculates the true elevation and true bearing of the star (data that permits a digital navigation table to determine a correction for the gyros) but generates control signals to stabilize the periscope during star tracking.

Figure 1 shows the over-all Polaris navigational system. The Stardac computer receives measurements of heading, roll, and pitch from the Ship's Inertial Navigation System (SINS); predicted elevation and bearing and rate of change from NAVDAC, a digital navigational almanac that contains tables of data for stars used as tracking aids; a quantity

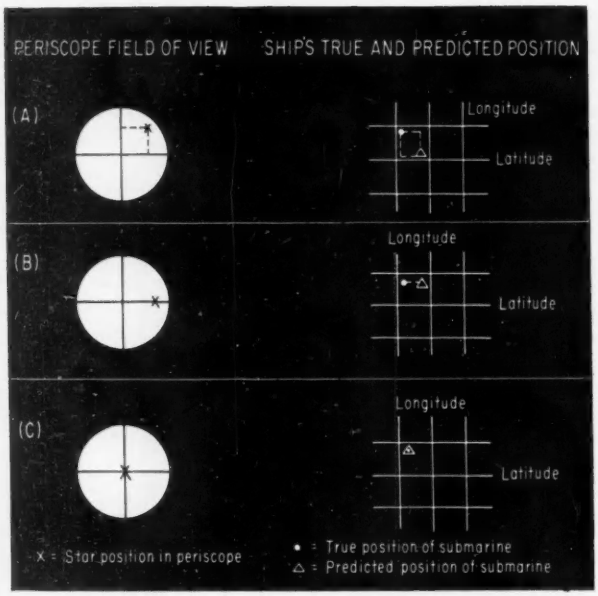


FIG. 2. What the submarine captain sees through the periscope when star sighting. At top, star is not at center of crosshairs. Captain brings star's position in view to crosshair intersection with a joy stick control.

to compensate for misalignment between the gyros in SINS and the optical reference of the periscope; and a sighting correction made by the navigator's joy stick control. From this data, Stardac performs a coordinate transformation, changing the submarine's three rotational degrees of freedom into a two-dimensional field, in real time, to stabilize the periscope during the star-sighting, and finally computes the true elevation and true bearing which NAVDAC compares to SINS' calculated values to determine the corrections for the gyros.

To make a reading, the navigator primes NAVDAC to select an appropriate star to sight—the choice depends on the sub's approximate latitude and longitude and the time of day. The digital navigational table calculates a predicted bearing, bearing rate, a predicted elevation (angle to the star) and elevation rate to the chosen star (rate data is the correction to compensate for the rotational speed of the Earth), and transmits this data to Stardac.

At the same time, the sub's motions—pitch, roll and heading—are measured by SINS and continuously fed to Stardac. Corrections for pitch and roll mast flexure are determined by an auto-collimeter and transmitted once per star tracking to Stardac. The computer processes these data to stabilize the periscope so the crew has a stable platform from which a fix can be taken.

When an observer looks through the periscope he sees something like the field of Figure 2A—the star translated from the crosshair intersection. This means the sub's actual position does not exactly coincide with the one predicted by NAVDAC. The observer moves the star into the exact center with a joy stick control. Pulling the control lever down moves the star downward in the periscope's field of view. Moving the joy stick right or left completes the translation. When a star is in the exact center of the periscope's view, the observer marks it (Figure 2C). The analog parameters generated by the joy stick control are sent to Stardac where they are converted to digital form. These are the exact error correction quantities; they are added to the predicted bearing and predicted elevation data, supplied by NAVDAC, to yield the true bearing and true elevation of the star.

The measured bearing and elevation is transmitted to NAVDAC which processes the data to generate output correction information. Corrections are then sent to SINS to modify the reference gyros. Several star-sighting operations supply sufficient data to calculate the ship's true bearing and position.

Stabilizing the periscope

The measured bearing and measured elevation is calculated but once a reading. Stardac's main job is solving two equations in real time to stabilize the periscope. The solutions feed anticipatory motion of the periscope to its servos. The stabilization equations are:

$$\tan Bd = \frac{\cos E \cos R \sin B + \sin E \sin R}{\cos E \cos B \cos P + \cos E \sin B \sin R \sin P - \sin E \cos R \sin P}$$

$$\sin Ed = \sin E \cos P \cos R + \cos E \sin P \cos B - \cos E \cos P \sin B \sin R$$

where, in Earth coordinates,

E = elevation
R = roll
P = pitch
B = relative bearing

and in boat coordinates,

Bd = deck train, the azimuth angle of the periscope line of sight measured in the plane of the ship's deck.
Ed = deck elevation, the elevation angle of the periscope line of sight measured from the plane of the ship's deck.

Stardac has no distinct arithmetic, memory, or

Characteristics of STARDAC

type	digital
function	special purpose
mode	real time
timing	synchronous
component design	solid state
programming	fixed program
arithmetic system	binary
position of decimal	fixed point
problem solution	serial
clock frequency	250 kc
complete computational cycle	39.848 millisec

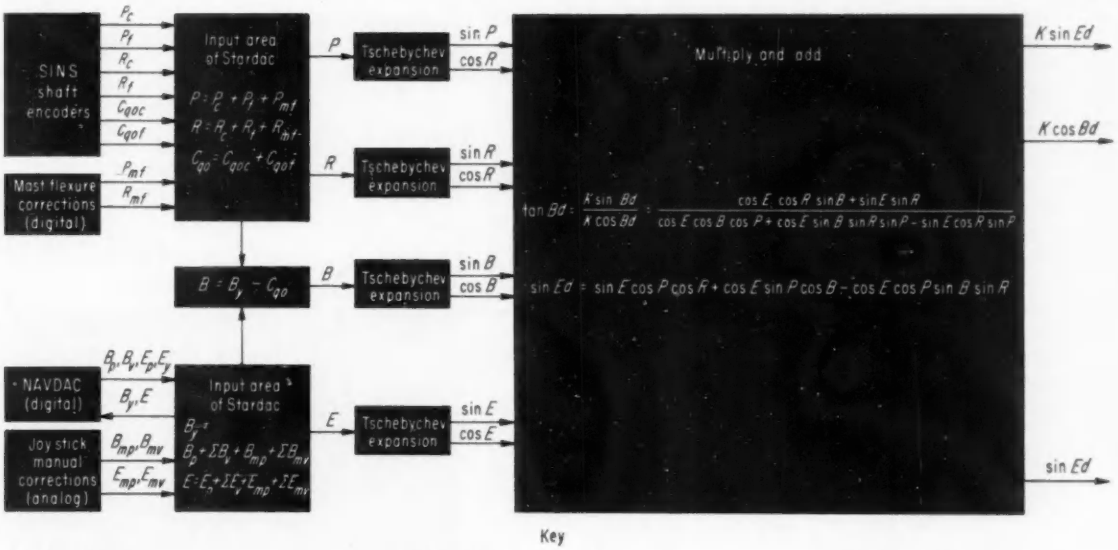
program unit. It combines all three functions by using multiple parallel computing channels. The result is a computational speed equivalent to that of a computer with a three megacycle arithmetic unit and separate storage. In its computation, the machine uses both conventional binary arithmetic and incremental techniques.

Stardac's incremental technique generates trigonometric approximations with extremely high accuracies by simple arithmetic computation. In the dynamic computation, each solution has an error—small but finite—due to rounding off, trigonometric approximations, and quantization. But the error is not accumulated from solution to solution because the error in one is corrected in the next solution by a digital feedback loop.

For example, the machine computes an exact correction every computer cycle to update the previous solution of the deck train and deck elevation equations. This approach means a big saving in hardware because the machine does not have to compute a complete new solution every computer cycle. Memory time is only three computer cycles. Therefore Stardac has an extremely fast response time in switching from one star problem to another. Transient errors that might be induced by spurious pulses will be cleared out of the machine within three computer cycles—120 millisec.

How the computer solves the stabilization equations—and converts motion in a three-dimensional space to a two-dimensional space—is shown in Figure 3. After the elevation, roll, pitch, and bearing quantities have been assembled from their various components in the input area, their sines and cosines are simultaneously computed to an accuracy of 1 part in 10^7 for the sine and 1 part in 10^6 for the cosine by a *Tschebychev* expansion. These accuracies are realizable by confining the *Tschebychev* polynomial to a 90 deg interval, from 0 to 90 deg. (Since pitch and roll are actually confined to a much

FIG. 3. How STARDAC computes deck train and deck elevation—first step. Key to computation is use of the Tschebychev expansions (see box next page).



Key

P = true pitch
P_c = pitch coarse
P_f = pitch fine
P_{mf} = pitch mast flexure correction

R = true roll
R_c = roll coarse
R_f = roll fine
R_{mf} = roll mast flexure correction

C_{go} = true ships heading
C_{goc} = ships heading coarse
C_{gf} = ships heading fine

B = relative bearing of boat
B_y = true bearing with respect to north
B_p = predicted bearing of star
B_v = bearing rate due to Earth's rotation
B_{mp} = bearing position manual correction
B_{mv} = bearing velocity manual correction

E = true elevation
E_p = predicted elevation of star
E_v = elevation rate due to Earth's rotation
E_{mp} = elevation position manual correction
E_{mv} = elevation velocity manual correction

Bd = deck train
Ed = deck elevation

A SINE-COSINE GENERATOR—
A Typical Logic Element in Stardac

Here is how designers of Stardac mechanized the Tschebychev expansions. A Tschebychev expansion for the sine of an angle is:

$$\sin X = C_1X - C_3X^3 + C_5X^5 - C_7X^7$$

which may be rewritten as

$$\sin X = X\{C_1 + X^2[-C_3 + X^2(C_5 - C_7X^2)]\}$$

Similarly,

$$\cos X = C_0 - C_2X^2 + C_4X^4 - C_6X^6$$

or

$$\cos X = C_0 + X^2[-C_2 + X^2(C_4 - C_6X^2)]$$

For a sine-cosine expansion using a 26-bit word all odd steps are 26 pulse transfer and add cycles. All even steps are 676 (26 by 26) pulse multiplication cycles. The operation is straightforward serial multiplication, with positive binary numbers and MSB = 90 deg. Multiplier registers are shifted only once per minor cycle (every 26th pulse) to gate or not gate continuously a recirculating multiplicand into continuously recirculating product registers. Recirculation on product registers is tapped one bit time early to allow the constant shifting right necessary in adding new partial products to form final product at end of 26th minor cycle. Binary point in product registers is at extreme left. Rounding off is used in all multiplications.

narrower range of values than 0 to 90 deg, modified Tschebychev coefficients are used which actually make the sines and cosines of P and R accurate to 1 part in 10^8.) Simple logic accommodates angles outside this range.

The greatest single source of error in Stardac is computational time delay. When the solutions of Bd (deck train) and Ed (deck elevation) are obtained, the point at which the periscope should have been directed 39.848 millisec ago is now accurately known. At the maximum slewing rate of these quantities, the errors caused by such a delay are too large by at least an order of magnitude, but a detailed analysis of the dynamics of the problem indicates that a second order extrapolation makes it possible to meet the accuracy specifications.

Because the increments in the output at high dynamic rates are large enough to block the high performance servo amplifiers of the periscope, the data as presented to the servos are smoothed between 39.848 millisec samples.

The computer has to perform a simple extrapolation to determine where the periscope should be pointing now, and continue this extrapolation in much smaller steps throughout the next sampling interval. This is shown in Figures 4 and 5.

At sampling time t_3 (Figure 5), the computer is at point C, having just completed the computation of the value of C' from the inputs that were sampled at time t_2. Because the computer stores the values obtained at points A and B, it can extrapolate and obtain point D. Since this operation is to all intents "instantaneous", point D is available at t_3 time for

Correcting for Time Delay

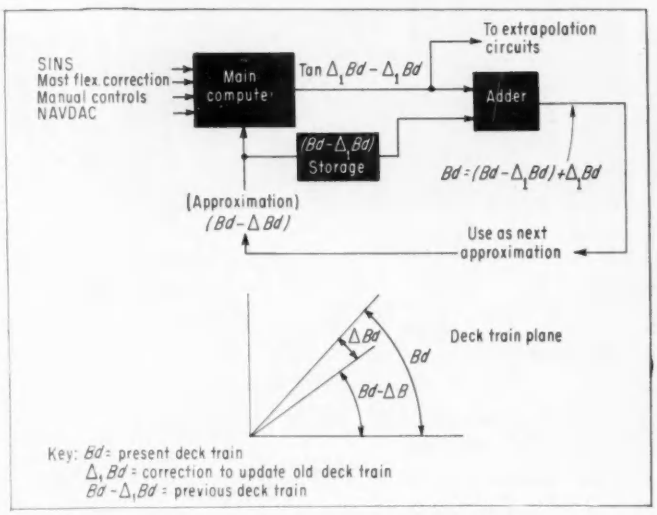


FIG. 4. Computer updating process is incremental. Correction is computed every computer cycle. Machine maintains value of previous deck train in registers.

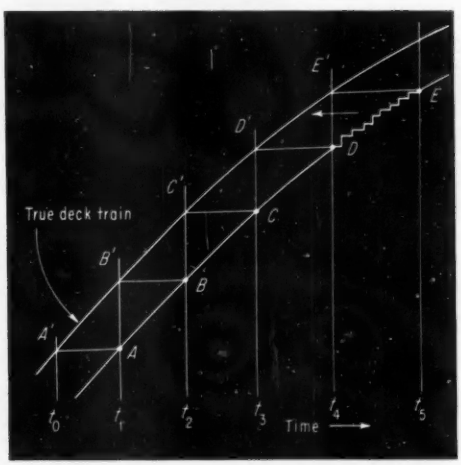


FIG. 5. How time delay affects computer output. At time t_3, computer calculates deck train (or deck elevation) to be A, but the true value has already reached B'.

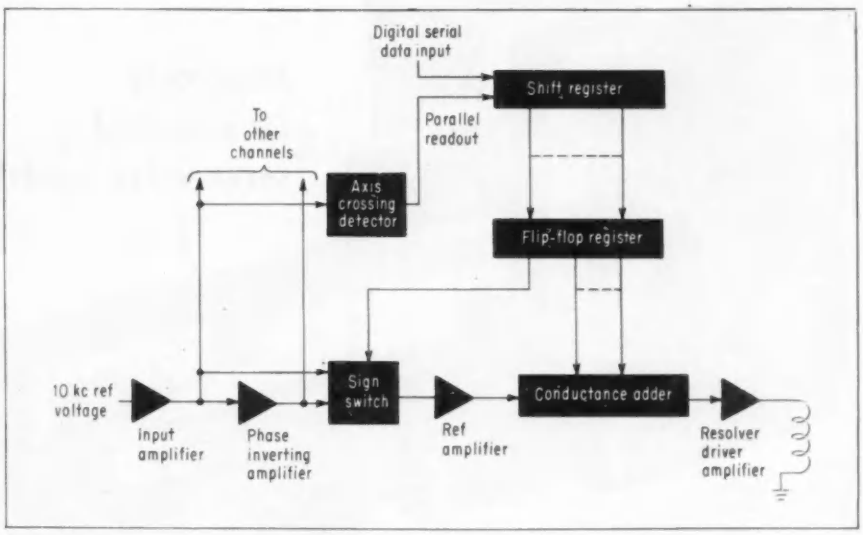


FIG. 6. Typical digital-to-analog converter.

presentation to the servo as an approximation to the true value D'.

The extrapolation is continued in small steps along what corresponds to the arc DE to supply a smoothed or filtered output. This information is available in the interval between t_3 and t_4 and is presented to the output as an approximation of the true arc $D'E'$. This computation, performed in the fine extrapolation circuits, constitutes a digital filtering operation.

The output

The output circuitry accepts a digital input word specifying an angle and converts this to a form that serves as a command input to the periscope servo. The systems are typical high performance position servos employing resolvers for the transmission and indication of angle. To obtain the necessary accuracy, a two-speed system is employed having a speed ratio of 180 to 1. In an installation, the command resolvers are simulated electronically by the output circuits of Stardac and the resolver receivers are located in the periscope control console.

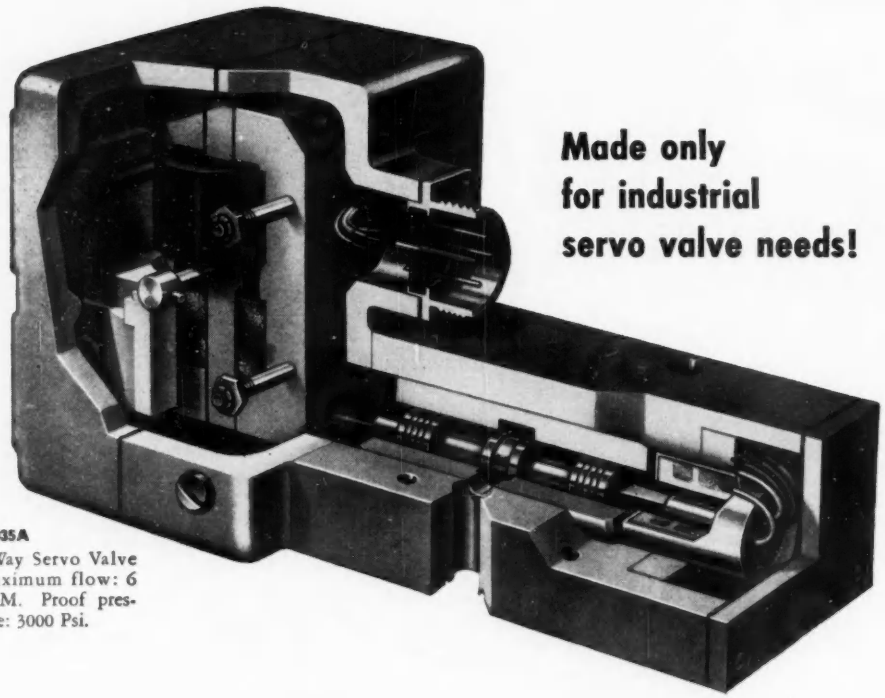
After the angle (for example, deck train), at which the periscope is to point is determined, the following operations take place:

- The angle is broken up into its coarse and fine components, the coarse component indicating the angle at which the single speed resolver should be pointing, and the fine components the angle of the 180 speed resolver.
- The sine and cosine of the coarse and fine angles are generated in a *Tschebychev* expansion (see box, page 104).
- Each serial word is fed into a magnetic shift register.
- At the proper time the information is transferred in a parallel readout to the digital-to-analog circuits (Figure 6).

The analog output is a 10 kc voltage in which the magnitude of the quantity is represented by the magnitude of the voltage and the sign of the quantity is represented by the phase. Since each servo system has two resolvers, and each resolver requires two inputs (an input proportional to the sine of the commanded angle and an input proportional to the cosine of the commanded angle), eight digital-to-analog output circuits are required for complete control of the periscope.

A block diagram of one digital-to-analog channel is shown in Figure 6. Two inputs are necessary for the channel, a 10 kc reference voltage from the periscope console and the digital word from the computer. Two input amplifiers (common to all eight channels) set the voltage level and provide two voltages 180 deg out of phase.

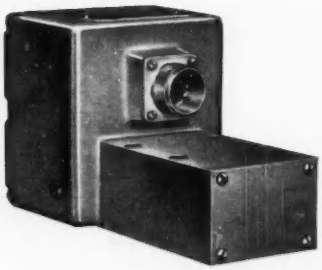
The digital information is held in the shift register until a readout signal is received, causing parallel readout to the flip-flops of the converter. The timing of this transfer is controlled by the Axis Crossing Detector and other logic so that it is accomplished at the time the 10 kc signal is going through zero, thus reducing the effects of switching transients. The flip-flops control switches in the conductance adder to provide an output proportional to the digital value stored in the flip-flops. The first flip-flop (the sign flip-flop) controls the sign switch selecting the proper phased reference voltage for the conductance adder. The output of the conductance adder is fed to a resolver driver amplifier that supplies the gain and power necessary to drive a resolver winding.



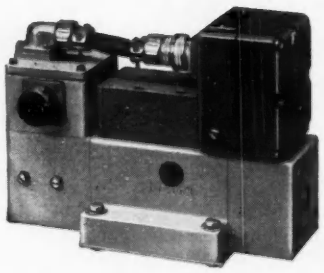
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V7035A
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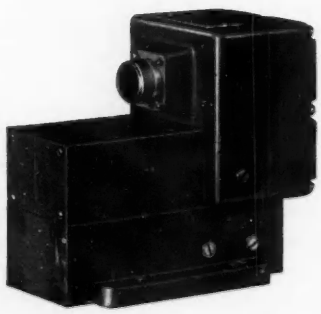
V7037B
4-Way Servo Valve
Available in ranges from 50 cu. in/min. max. to 4 gals./min. max. at 1000 Psi. Proof pressure: 3000 Psi.



V7040A
2-Stage Servo Valve
Maximum flow: 40 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.



V7041A
2-Stage Servo Valve
Maximum flow: 15 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.



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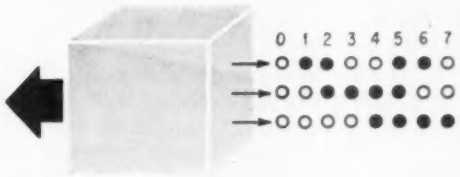
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H HONEYWELL SINCE 1885 *First in Control*



Digital Transducer:
Force input . . . Binary coded output

THE GIST: Here's a unique transducer that uses a little known optical effect to convert a force to a binary signal. This is no analog sensor with a concealed analog-to-digital converter, but a true digital transducer. Photoelastic materials such as Bakelite and epoxy modulate beams of light to produce a Gray code output representing the stress in the material. Any variable convertible to a force can be measured. A 3-bit breadboard model has been built, and tiny units with 0.1-1.0 percent accuracy appear feasible.

FRED A. LUDEWIG, JR.
General Engineering Lab., General Electric Co.

Why a sensor with digital output? Digital data can be transmitted, stored, and read repeatedly with little loss in accuracy (Ref.). All these operations distort the output signals of conventional analog instruments. Although sensors with digital output (a series of discrete contact closures or voltages in binary or other coded form) would be directly compatible with digital computers, they would also be useful in non-computer applications. A line of commercially available digital sensors might lead to simple, high accuracy digital control systems.

Photoelastic materials digitize stress

Certain optically transparent materials are photoelastic; when stressed, they effectively rotate the plane of polarization of light passing through them. The amount of rotation is a function of the material, its thickness, the stress, and the wavelength of the light. Suppose a section of photoelastic material is placed in a polarized, monochromatic light beam, Figure 1A, and the transmitted light intensity is monitored through a Polaroid analyzer. When a load is applied to cause uniform tensile stress in the section, the light intensity varies as shown in Figure 1B. The intensity is proportional to the sine squared of a constant times the stress, the constant being a function of the material and its thickness and the wavelength of the light. With a suitable detector, the relation between stress and elec-

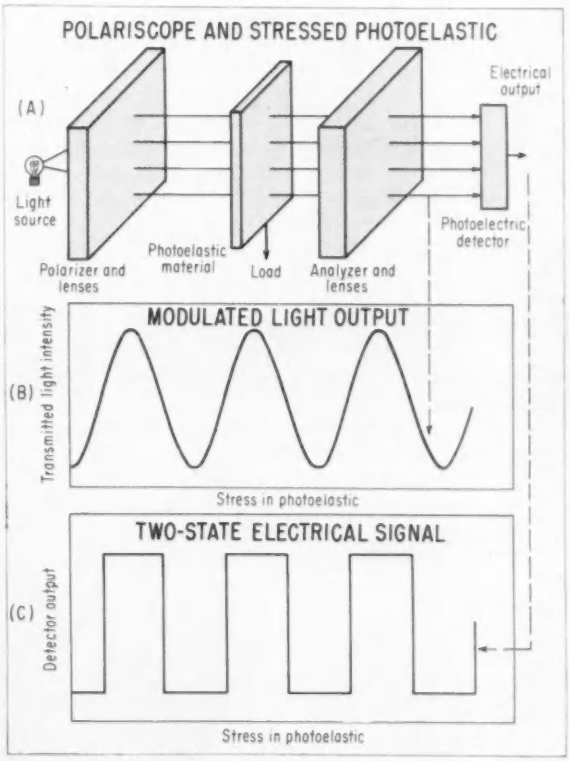


FIG. 1. Light transmitted by polariscope (A) varies cyclically (B) as photoelastic material is stressed; detector output can be made 2-state (C).

trical output can be made that of Figure 1C. Neglecting the small residual dark signal, the output is either zero or some maximum value.

Now consider a piece of photoelastic material, Figure 2A, shaped so that adjacent sections, labeled *A*, *B*, *C*, *D*, and *E*, have cross sectional areas related as 1:2:4:8:16. The light transmitted by each section is focused on a separate detector. A unit load will be defined as the load that stresses section *A* enough to change the output of detector *A'* from one state to another. This load divided by the cross sectional area of section *A* is the unit stress. For a given load, the section stresses are as $1:\frac{1}{2}:\frac{1}{4}:\frac{1}{8}:\frac{1}{16}$.

As the load increases, the detector outputs (assuming the 2-state characteristic of Figure 1C) vary as in Table I. Output states are denoted by a zero, meaning no output, or a 1, meaning maximum output. The outputs are identical to the Gray (reflected binary) representation of the numbers zero through 31, so this device is a force sensor with parallel Gray-coded digital output. Other photoelastic configurations can give the same result as long as the detectors are positioned so that the stresses follow the $1:\frac{1}{2}:\frac{1}{4}:\frac{1}{8}:\frac{1}{16}$ progression.

Table II lists some typical photoelastic materials and their unit stress values (based on a thickness of 1 in. and a light source wavelength of 5,461 Angstroms). Catalin 61-893 can be loaded to about 90 times the unit stress before reaching the elastic limit. This means that the smallest section can go through 90 output alternations (360 unique states in Gray code), and that a device made of Catalin 61-893 is capable of 0.28 percent resolution. By placing a system of mirrors on each side of the material so that the light beams pass back and forth through a given section 3 times, the effective unit stress can be reduced by a factor of 3. The resolution is then 1 part in 1080 or about 0.1 percent.

Many variables such as pressure, displacement, acceleration, current, voltage, and temperature can be converted to forces, so a successful design would lead to a whole family of digital transducers.

Breadboard model works as predicted

To prove the optical and electronic circuits, a three-stage (3-bit) demonstration model was con-

DIGITAL SENSOR:

THEORY . . .

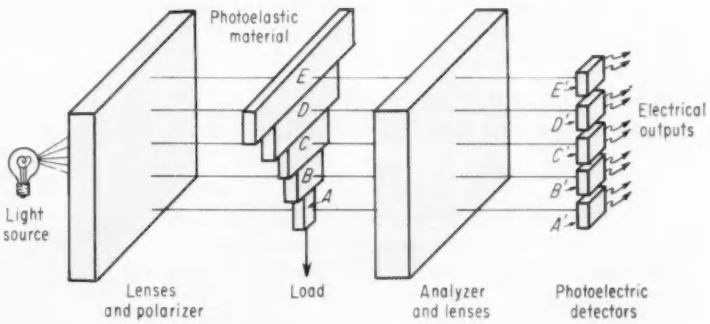


FIG. 2. Parallel Gray code output represents stress.

. . . AND PRACTICE

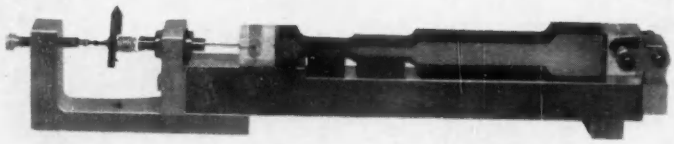


FIG. 3. Three-stage epoxy sample is stressed lengthwise.

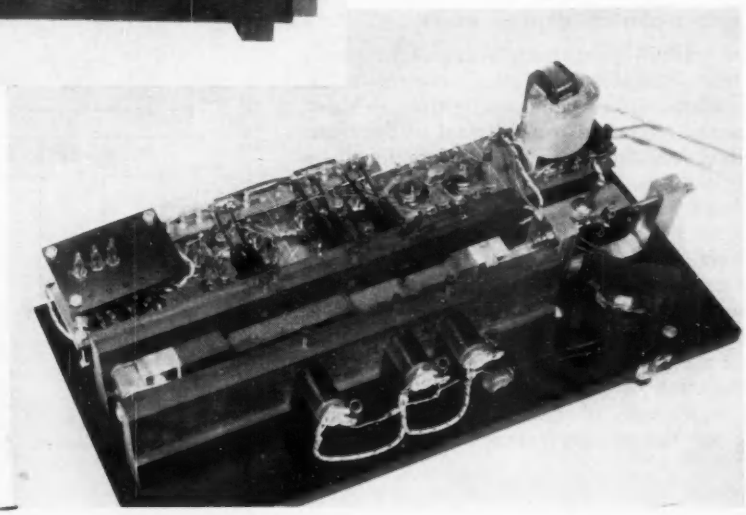


FIG. 4. Applied force is read out on indicator lights at upper left.

structed using a Hysol No. 8705 polyurethane rubber stress member. Samples of Hysol No. 8705 showed linear output and no hysteresis up to at least 18th order fringe—equivalent to a full scale reading of 72 with plus or minus 1 percent resolution. The three-stage model has a full scale of 7, and 1 part in 7 accuracy. After machining, the ½-in. wide by 6½-in. long stress member was mounted in an assembly, Figure 3, for applying a tensile load. The complete transducer, Figure 4, uses GE No. 243 bulbs as light sources. Filters obtained from Baird Associates, which pass a wavelength of 615 plus or minus 5 millimicrons, are mounted in front of the bulbs. The polarizing and analyzing plates are Polaroid HN-22, and the photocells are Clairex CL-407.

Transmitted light intensities versus load for the three sections are shown by the solid sine-squared curves in Figure 5. The points on the curves marked *a*, *b*, *c*, *d*, *e*, *f*, and *g* (where the superimposed square wave and the sine-squared wave intersect) show where the detector output should change from 0 to 1 or 1 to 0. To do this with one detector per section, the intensity must be measured absolutely.

TABLE I — DETECTOR OUTPUT STATES

Unit loads	Detector E′	Detector D′	Detector C′	Detector B′	Detector A′
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	0	1	1
3	0	0	0	1	0
4	0	0	1	1	0
5	0	0	1	1	1
6	0	0	1	0	1
7	0	0	1	0	0
8	0	1	1	0	0
9	0	1	1	0	1
10	0	1	1	1	1
11	0	1	1	1	0
12	0	1	0	1	0
13	0	1	0	1	1
14	0	1	0	0	1
15	0	1	0	0	0
16	1	1	0	0	0
17	1	1	0	0	1
18	1	1	0	1	1
19	1	1	0	1	0
20	1	1	1	1	0
21	1	1	1	1	1
22	1	1	1	0	1
23	1	1	1	0	0
24	1	0	1	0	0
25	1	0	1	0	1
26	1	0	1	1	1
27	1	0	1	1	0
28	1	0	0	1	0
29	1	0	0	1	1
30	1	0	0	0	1
31	1	0	0	0	0

TABLE II

Material	Unit stress (lbs/sq in.)
Glass	2,000
Lucite	600
Cellulose nitrate	200
Castelite (Paraplex P-43)	130–160
Bakelite (Catalin 61–893)	86
Columbia resin No. 39	85
Epoxy (Hysol-6000 series)	60
Soft epoxy resin	0.5
Gelatin	0.15

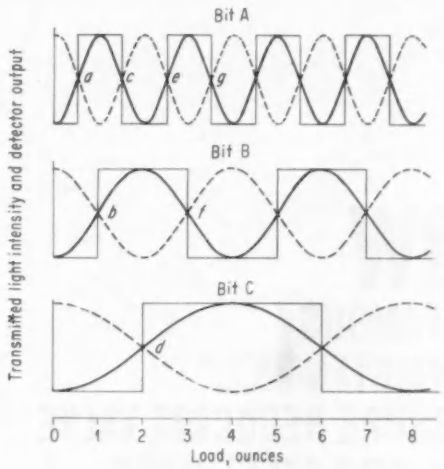


FIG. 5. Detector output changes state where sine-squared curves intersect.

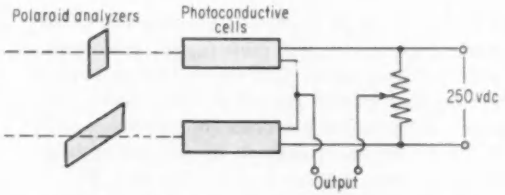


FIG. 6. Bridge compares outputs of crossed detectors.

The electrical output of the photocell is a function of light source intensity (which varies with the fourth power of filament current), transmission losses, photocell characteristics, and electrical reference. To divorce the output change decision from these dependencies, another analyzer—set at 90 deg to the original one—and a second photocell are added to each section, Figure 6. The dashed curves in Figure 5 are the outputs of these new detectors. The detector outputs are equal at the decision points, so the decision can now be made by comparing detector outputs. This decision will be based only on the stress in the material and the relative characteristics of the photocells.

The two cells and the tapped resistor in Figure 6 form a bridge that senses the ratio of the cell resistances. When this ratio passes through unity, the output of the bridge changes polarity. The output is applied to a 2N294 unijunction transistor that is biased to conduct and to fire an NE76 neon indicator lamp whenever the bridge output exceeds plus 1 volt. The three-stage unit requires three of these bridge/switching circuits.

The breadboard sensor described above has performed consistently in repeated demonstrations. Results show that a 1 percent accuracy sensor for room temperature applications can be built slightly larger than a pack of cigarettes. Ultimate accuracy is probably on the order of 0.1 percent.

REFERENCE

WHAT ABOUT DIGITAL TRANSDUCERS?, E. J. Kompass, "Control Engineering", pp. 94-99, July, 1958.

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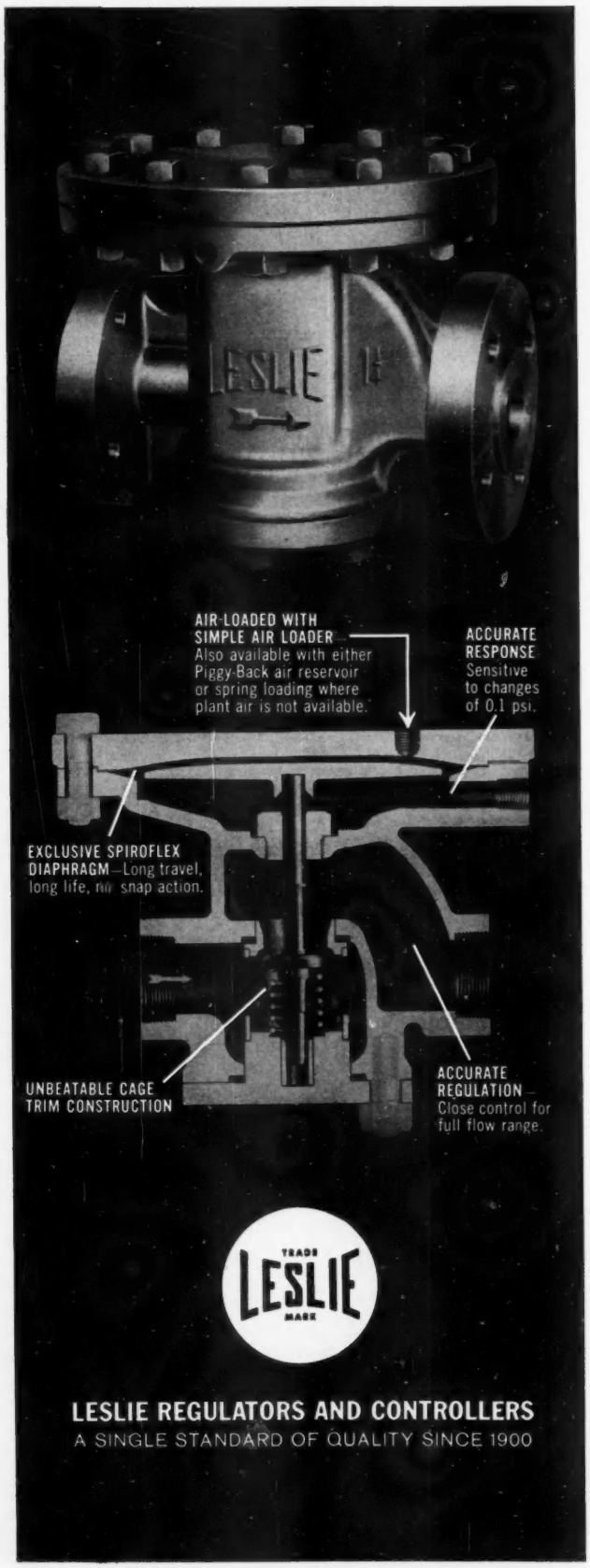
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The DC-8 That Didn't Fly

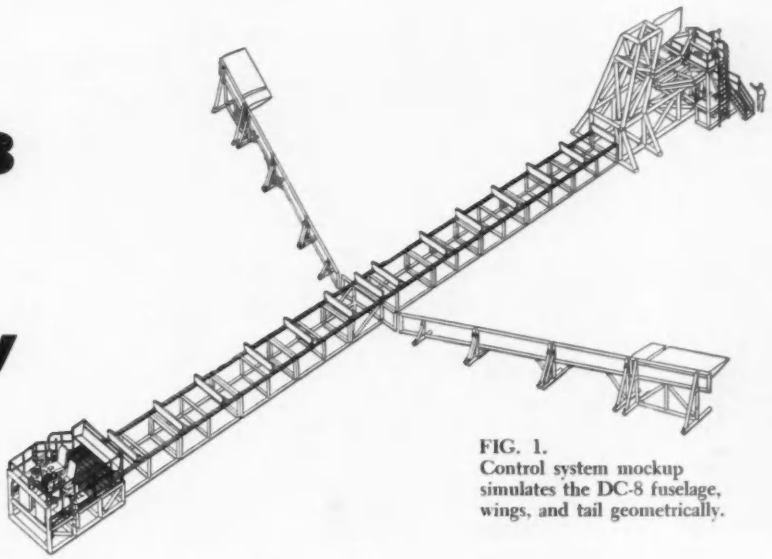


FIG. 1.
Control system mockup simulates the DC-8 fuselage, wings, and tail geometrically.

One way to speed control systems development and test is with a full-scale mockup. Although such replicas are common in the aircraft industry, few have relied on them as heavily as Douglas Aircraft did in the DC-8 program. Faced with an ambitious delivery schedule, the company had to slash time. A control systems mockup cut development time, saved flight time, and eliminated over 2,000 hours of test setup normally required on the ramp.

R. V. FORMAN
Douglas Aircraft Co.

When Douglas Aircraft Company entered the jet commercial transport field, it found itself trailing its biggest competitor by several years. To catch up and meet an ambitious delivery schedule, the company introduced a number of time cutting procedures, such as the use of a control systems mockup. In the mockup, control hardware was assembled and tested so that components could be examined in their systems environment early enough to make design changes with a minimum disturbance to the flight test or production programs. An intensive laboratory shakedown was performed on the DC-8 jet liner control system while the first aircraft was still being assembled.

The mockup not only cut months from the testing schedule, but led to better designed control components before too much production effort was wasted. For example, when adverse pressure surging was spotted in the hydraulic system of the surface controls, a selector valve design was changed to assure smooth fluid control. With a breadboard analog computer, the best gain settings for various flight conditions were determined for the autopilot—in advance of flight tests.

Testing on the controls mockup was divided into four types: 1) systems performance, 2) reliability and safety, 3) pilot familiarization and evaluation, and 4) flight test backup and assistance. Each type of testing had to verify the basic design and to determine whether preliminary operational requirements were satisfied. For example, in the systems performance study, static characteristics such as friction, spring rate, and backlash (for both the primary surface controls and the trim controls) were measured and found well within design limits for smooth and positive control even with adverse load variation. Some improvement, however, was required in control forces.

To get information, Douglas engineers started with a precision laboratory testbed (Figure 1) designed from loft data and structural drawings of the DC-8 fuselage, wings, and empennage (aircraft tail). Constructed of large diameter pipe, it was segmented for easy handling and alignment during installation; the segmentation also minimized variations due to thermal effects and the application of test loads. Structural mockup components were installed just like tooling fixtures, anchored to concrete ballast. Steel plates and brackets were placed to simulate the bulkheads, spar planes, and other aircraft members to which control system components would be attached in an actual airplane. Dimensional accuracy was maintained so that control system cable lengths were identical with those in the aircraft.

The test facility contained all primary and secondary flight control systems. Installed to production drawings were such primary systems as elevators, an aerodynamic boosted system, aileron and rudder systems, which are normally full hydraulic powered with tab boosted or "manual" alternate mode. Also installed were secondary controls, separate systems

which function as force trimming controls, including an all-movable horizontal stabilizer on the longitudinal axis.

In addition engineers incorporated such accessory controls as nose wheel steering and main gear brake with rudder pedals. Both of these were rudimentary. Nose wheel steering terminated as a foreshortened trunion assembly, and expansion chambers simulated brake oil volume for the main gear system.

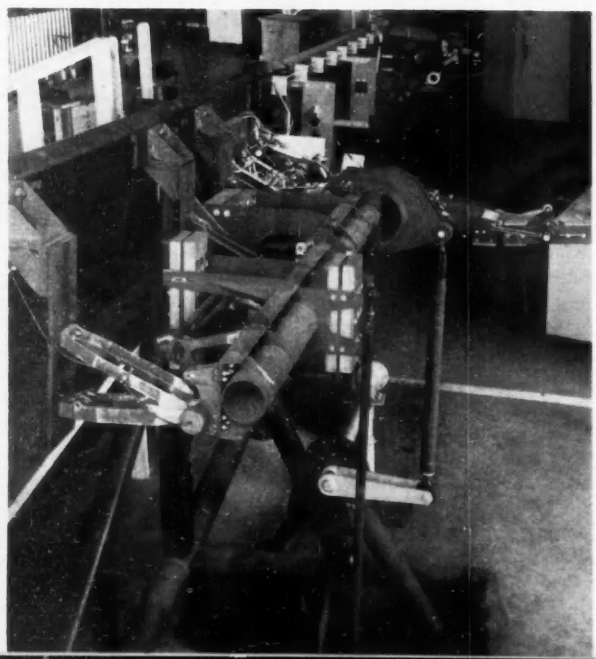
The hydraulic system was reproduced as exactly as possible. Power was supplied by two 3,000 psi, 22½ gpm variable displacement pumps—just as in the DC-8. Lines lengths, comparable to those in the aircraft, were fabricated from the same diameter tubes and materials. Components for proper flow porting, pressure control fluid filtration, and storage duplicated those planned for the production model. Auxiliary pumping systems and all emergency power devices were integrated into the mockup.

Simulating loads and measuring effects

Because the control surfaces of the mockup were built to be functional, with proper mass and inertia effects, and furnish a rigid coupling to apply external loads, Douglas wanted to simulate realistic aerodynamic surface loads as well. To do this, the company built torsion spring loaders and secured them to concrete ballast. The springs were mounted adjacent and parallel to the hinge line of the control surfaces. Figure 2 shows the simulated loading close up.

To evaluate the controls over a wide range of flight conditions, test engineers set up almost 200 elements of instrumentation. The system was designed for maximum flexibility. For example, transducer leads terminated at a switchboard type patch panel so a tester could select channels for any combination of parameters. Visual display of pilot forces, surface positions, and hydraulic system pressure was presented in duplicate to the mockup cockpit and to the instrument control room (Figure 3) which looked down on the test bed. Both the mockup operator (pilot) and the control room observers could survey the motions of the test control system on all axes continuously. The instrumentation console next to the mockup contained oscillograph, oscilloscope, X-Y plotter, and temperature recorders, which gave a total of 75 data channels.

FIG. 2. Simulated loadings on the mockup's left wing. Torsion spring assembly consists of a solid inner rod with a crank arm linked to the surface and an outer hollow tube splined to the rod at the end opposite from the crank. The outer tube is secured to a supporting A-frame at the crank end.



Technical Payoff

Because Douglas had built a duplicate of the DC-8's cockpit onto the test bed to evaluate a pilot's reaction to the controls, it was logical to run the systems from the cockpit. Data and observations were then recorded, and test engineers could establish the fundamental characteristics of surface rate (response), stability, and positionability.

One important specific test was the determination of the available rate of angular surface travel with the effects of surface damping devices and simulated aerodynamic loads. Manual inputs at various rates and direction were applied to the cockpit controls while system operating parameters such as surface position and hinge moment, cockpit forces and positions, and hydraulic pressure were recorded as functions of time.

Examination of oscillographs from preliminary tests showed that the available surface rates were lower than desired. With maximum pilot effort, the rate of aileron travel was marginal for correcting in a critical crosswind condition. This discovery led to a modification of system response by the installation of hydraulic control valves with higher gain characteristics at the surface actuators. A number of valves were tried until the desired rate improvement was obtained—at proper cockpit input levels. After stability tests the increased gain valve assembly specifications were released for production.

Tests were conducted with the powered aileron and rudder to verify that the control system installations were not subject to instability. At first, artificial damping devices were removed and the airload simulator springs were disconnected. To excite instability, testers pulsed various segments of the system from both the input and output directions. The tests were conservatively performed by introducing excessive "slop" into the hydraulic servo control linkages. Although no instability was seen in these tests, the system stability was studied further during frequency response tests.

Over-all system response characteristics were examined by applying step and sinusoidal inputs to the cockpit control. Force and position transducers were installed at the cockpit control; surface output elements and such devices as surface dampers, airload springs, and servo valve dampers were placed

where needed. A separate electrohydraulic servovalve, driving a power cylinder connected to the cockpit control, provided the necessary input to the mockup system. Dynamic response of the system was obtained directly by oscillating the driving cylinder at various combinations of frequency and force and monitoring the surface output phase and gain relationships. Control engineers were satisfied with the stability of the design because no unstable modes were encountered during these frequency response tests. The engineers evaluated the systems similarly from the standpoint of autopilot inputs.

The autopilot components were put to other tests in the prototype too. In addition to setting optimum gains, engineers tried "hardover" tests under the most critical conditions. Thus they were able to acquire the actual control system constants to replace theoretical values in problem analysis.

Another series of tests were aimed at evaluating the characteristics of the hydraulic system. Controls were operated on full hydraulic power, and surveys were made of pressure losses in both supply and return systems. Similar measurements were taken across critical components such as valves, filters, and manifolds. It was during these tests that the adverse pressure surging was measured, which led to a selector valve design correction.

Safety considerations are so important in commercial aircraft design that Douglas used the mockup for safety analysis too. Investigations and analysis of system reliability and safety were conducted as a parallel effort with the functional development stage. Safety devices integrated into the control system—such as the automatic power to manual reversion feature—were subjected to a systematic appraisal under the most critical conditions. Component malfunctions were simulated to observe system reactions and evaluate failsafe features. Static proof tests were performed to subject surface actuating load paths to hinge moments far exceeding those ever encountered in flight.

Tests along somewhat similar lines made in the mockup by test pilots gave early appraisals of cockpit force gradients so that proper control integration could be achieved. Pilot endorsement of over-all system characteristics such as positionability, ease of operation of secondary system controls, and general smoothness of the controls assisted greatly in obtaining what has been called a "pilot's" airplane.

Economic justification

The primary purpose of the control system mockup was to save time. As a time saver, it established a focal point for control system work divorced from production activities. System analysis was performed independently and swiftly, unhampered by the coordination and scheduling requirements that would have been encountered on a production airplane. The result: preliminary system tests were made several months in advance of a suitably operational aircraft system. Further time savings were realized throughout the flight test period. The location of the mockup near the Design Engineering Department proved to be a great advantage.

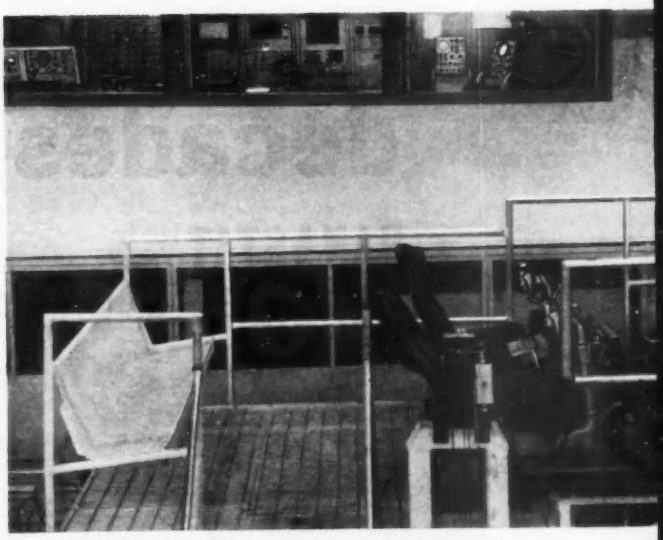


FIG. 3. Mockup from right side of cockpit. Balcony above flight deck contained central instrumentation and served as control center for test operations.

Other economic benefits have accrued too. The cost of the mockup structure, instrumentation and auxiliary test equipment, and personnel would have paid for only a fraction of the flight tests required to obtain the same information.

Even more important than the saving of flight test time was the elimination of aircraft ramp test operations. Parts changes, rigging adjustments and alterations, instrumentation checks, and no-load system tests—which require considerable time to set up in the flight confines of an actual airplane—were accomplished with comparative ease because of the high degree of structural simplicity and accessibility inherent in the mockup. Some delays due to the long lead times in the procurement of certain aircraft parts were never encountered because the laboratory mockup could use simplified or substitute parts in noncritical applications, a technique that could never be used on an aircraft. It has been estimated that 2,000 ramp hours would have been required had the tests been made on an aircraft.

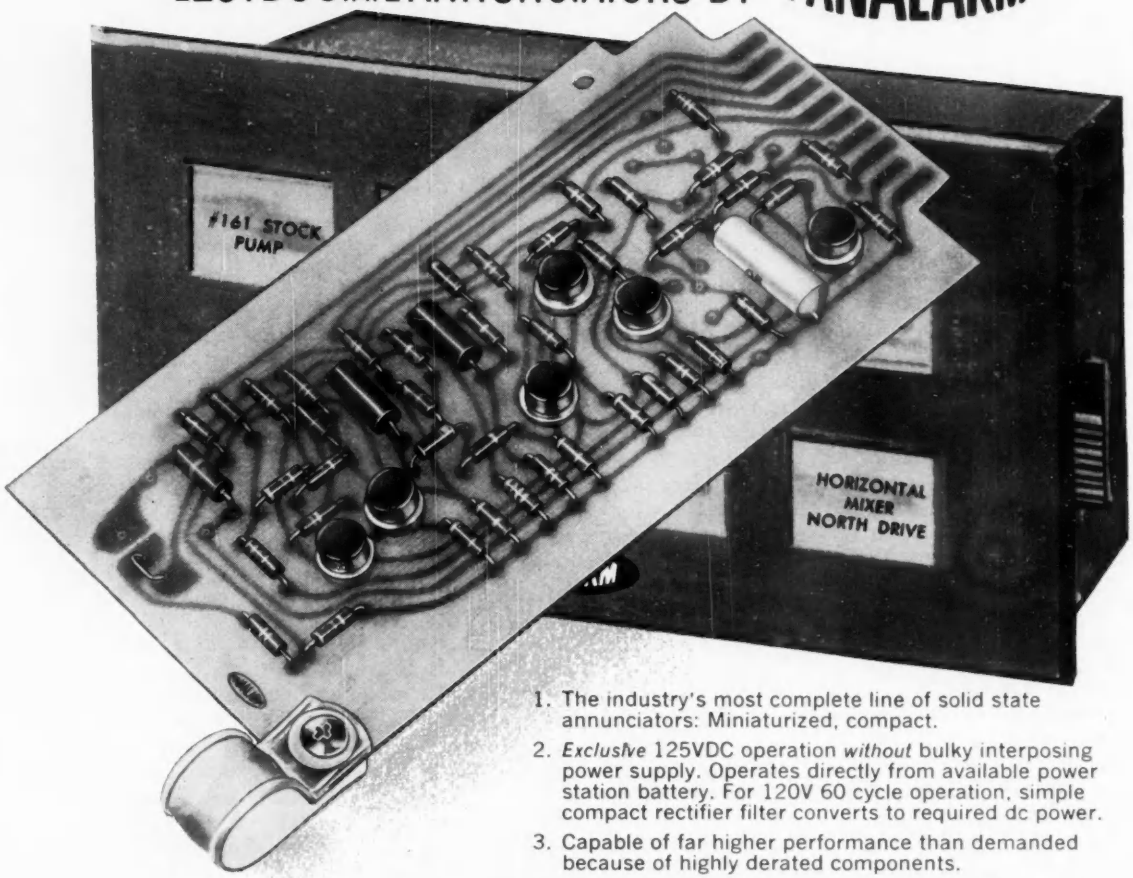
Numerous refinements have resulted from mockup testing. A few of the investigations made in tests included:

1. Anti-skid system valve development
2. Spoiler control system performance tests
3. Power cylinder stall and impact forces
4. Mach trim compensator performance test
5. Brake valve control refinement
6. Hydraulic pump performance tests

Another function the mockup has performed has been as a training aid for operators of the DC-8. The accessibility of hardware affords excellent observations of the mechanical functioning of all parts, an aid to maintenance and operations personnel.

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DATA FILE 49

Graph Checks Single Phasing of Servos

M. G. REKOFF, JR., Agricultural and Mechanical College of Texas

When the main winding of an ac servomotor is excited and the control winding is short circuited, the motor damps out any rotor motion by producing a torque in the opposite direction. But if the impedence in the control circuit, Z_c in Figure 1, is large enough, the motor may single phase and develop a torque in the direction of rotation when the control voltage is zero.

Figure 2 is the simplified per phase equivalent circuit of a servomotor. X_{lr} and X_{ls} are the rotor and stator leakage reactances, X_m the air gap reactance, r_r the effective rotor resistance, r_s the stator resistance, and s the slip.

A graphical construction based on these parameters divides all possible values of Z_c into two groups—those that cause single phasing and those that do not.

Lay out a rectangular coordinate system having $Re(Z_c)$ as the ordinate and $Im(Z_c)$ as the abscissa, dimensioning both axes in ohms. Now draw a circle with center and radius as shown in Figure 3. Values of impedence Z_c inside the circle result in nonsingle phasing operation, while values of Z_c outside the circle cause single phasing. The complete circle is not drawn because only positive values of $Re(Z_c)$ are generally available.

Figure 4 is a sample diagram for a Diehl FPE 25-11 servomotor with the following characteristics: $r_s = 310$ ohms, $X_{ls} = X_{lr} = 90$ ohms, $X_m = 970$ ohms, and $r_r = 685$ ohms.

This method assumes that the servomotor is frictionless, which implies that values of Z_c outside but near the boundary may not cause single phasing because the torque produced is less than the friction torque. This is not a serious error because other aspects of motor performance are poor for values of Z_c near the boundary on the inside.

The construction is wholly determined by servomotor equivalent circuit parameters. Such a diagram could be supplied by motor manufacturers as part of their servomotor performance data.

This procedure, presented here without proof, was developed using symmetrical components.

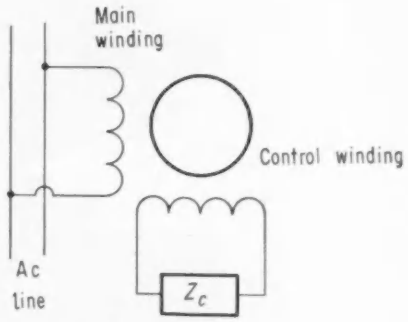


Fig. 1. If Z_c is too high, motor will single phase.

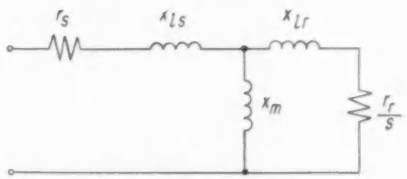


Fig. 2. Equivalent circuit parameters are identified in text.

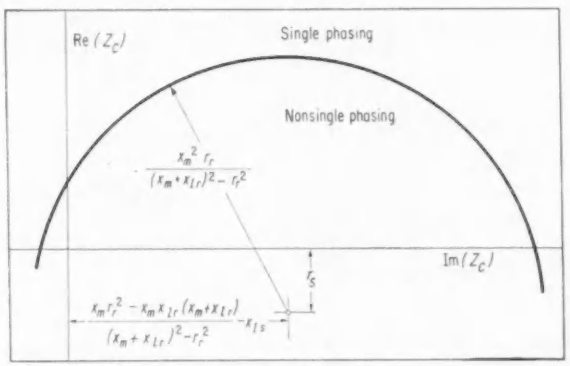


Fig. 3. Keep Z_c inside the circle for nonsingle phase operation.

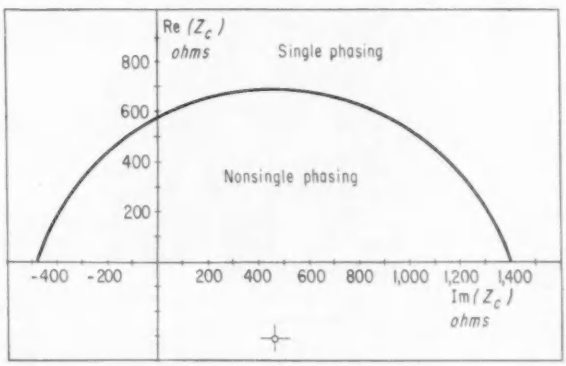


Fig. 4. Sample diagram for Diehl FPE 25-11 servomotor.

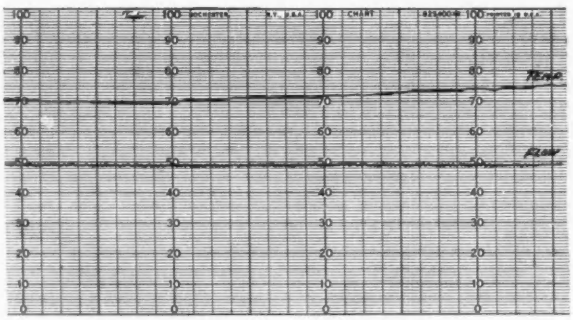
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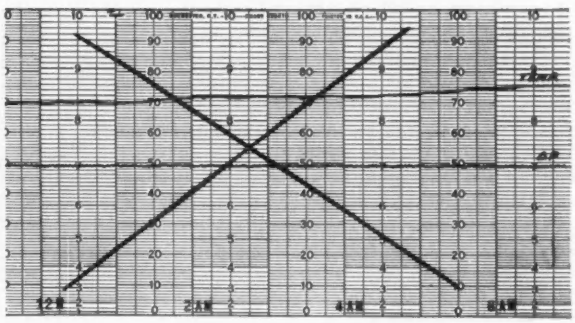
FROM



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**Even without this unique feature, the 212T would still be a superior DP transmitter.*



Convenient through-bolted flanges for easy servicing. Process connections top, bottom or side.



213T non-indicating model shows rear mounting and bottom process connections.

MEAN ACCURACY FIRST

High-Speed Switching with the Tetrode Transistor

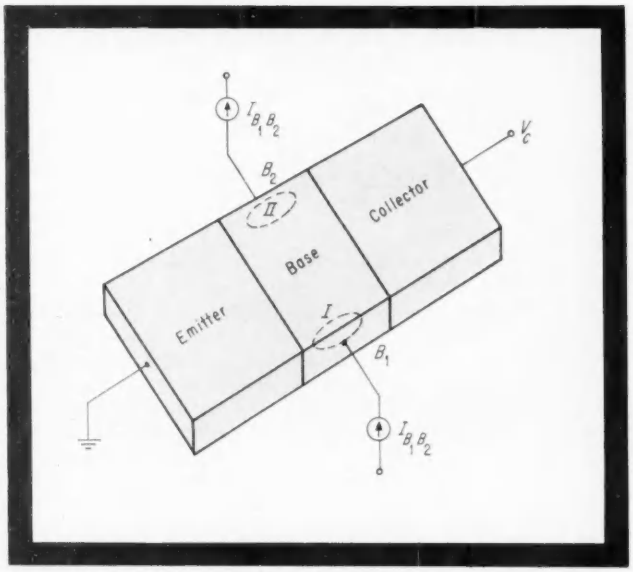


FIG. 1. Regions of a silicon tetrode transistor.

GIST: Tetrode action in a transistor—diffusion current crowds close to the contact of the fourth lead—reduces the base resistance so that frequency response of the device increases. This speed is most useful in nonsaturating circuits. By using tetrodes instead of triode transistors, a designer can reduce the number of semiconductor devices required: one tetrode can replace two triodes in such circuits. Here is a description of a high speed current-mode flip-flop that can be used in a high speed binary counter.

CHARLES R. COOK, JR.
JERRY LUECKE
Texas Instruments, Inc.

The figure above shows a silicon tetrode transistor. Instead of one lead to the base region—as you expect in a conventional transistor—the tetrode has two. This modification increases the frequency response of the device, making it useful in high speed switching circuits. With the extra base, the tetrode transistor can perform logic so that one tetrode replaces two triodes. Although it is more difficult to design, tetrode switching circuitry is cheaper and more reliable because it needs fewer components. The unique performance of the tetrode stems from the control of a bias current which may flow in either direction between the two base leads.

THE TETRODE ACTION

In the tetrode of Figure 1, when current is made to flow from B_1 to B_2, a voltage gradient appears, allowing only a small portion of the emitter-base junction to be forward-biased—region I near contact B_1. Therefore all the diffusion current crowds close to contact B_1. If the base is quite narrow this action (known as the tetrode action) reduces the base resistance r'_b and increases the device's frequency response (Ref.). At the same time the reduced active base volume means a loss in transport efficiency thus decreasing the low frequency and dc forward current transfer ratio (h_{FE}).

The tetrode is really two triode transistors with common emitter and collector leads. When only one base is connected, the tetrode is a triode. As a triode or tetrode there is no noticeable difference in dc or switching parameters when either base lead is used as the input.

That means the tetrode is ideally suited for NOR logic because each base can turn the collector current ON; the current will be OFF only if both bases supply negligible current for transistor action. So NOR logic is accomplished with tetrode action

by assuring base-to-base bias current flow. The current turns ON if the current from either base stops.

Supplying the base-to-base bias current also reduces the dc forward current transfer ratio (h_{FE}) from what it would be if the same input base is used for a triode. This occurs in addition to the loss in transport efficiency. And when base-to-base current bias is provided, breakdown can occur at contact B_2 (Figure 1). Breakdown leads to excessive leakage at the collector terminal. At first, these disadvantages to tetrode action appear discouraging. In the designs that follow, it will be shown how both of these disadvantages can be accommodated by careful consideration of circuit features and characteristics.

The high frequency response of tetrode action produces excellent rise and fall response times in switching circuits. If saturated circuitry is used, however, storage time will be the same or higher than that with triode action. One way to surmount this obstacle is to design nonsaturated circuitry that eliminates the storage time problem. Then tetrode action supplies the high-speed switching performance that is desired.

THE OLD WAY—WITH TRIODES

One way to realize the minimum switching time of given triode transistors is to put them in current-mode circuitry. There are two reasons for this: coupling capacitors and diodes can be eliminated in many logic circuits, and the transistors operate in a nonsaturated grounded base configuration.

CURRENT-MODE CIRCUITRY

THE OLD WAY

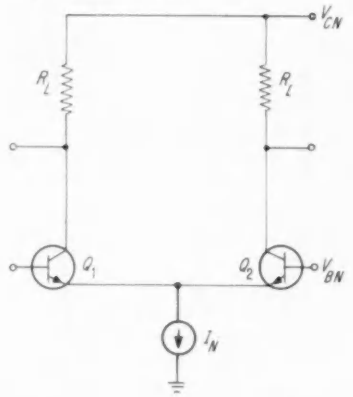


FIG. 2A. Simple switch, but output cannot be coupled to input of another.

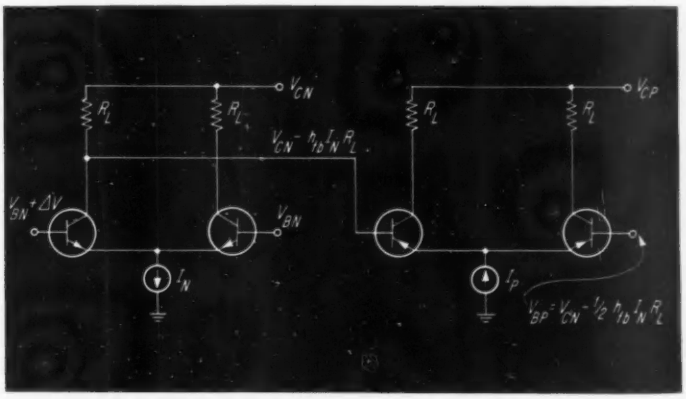


FIG. 2B. Complementary switch. Input and outputs are coupled but circuit has become expensive.

TRIODE VS TETRODE CIRCUITRY

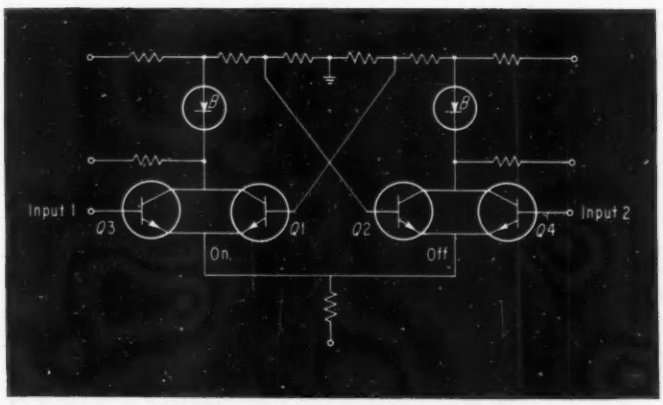


FIG. 3A. Current-mode flip-flop with triode transistors.

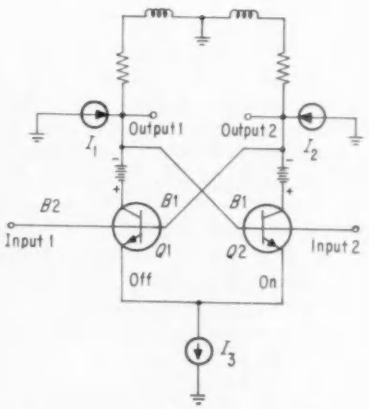


FIG. 3B. Current-mode flip-flop with tetrode transistors.

FULL RANGE TETRODE FLIP-FLOP

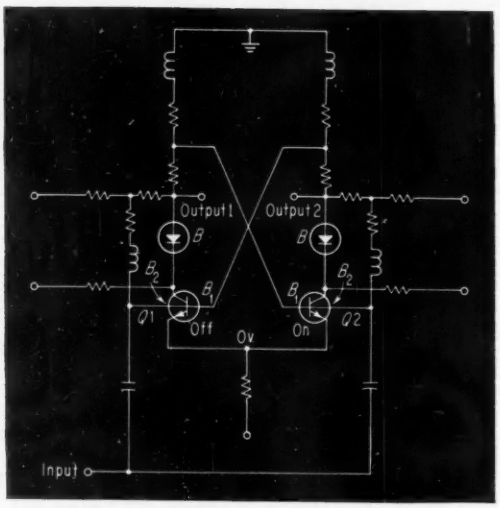


FIG. 4. Current-mode circuit with an input pulse repetition rate of 25 Mc.

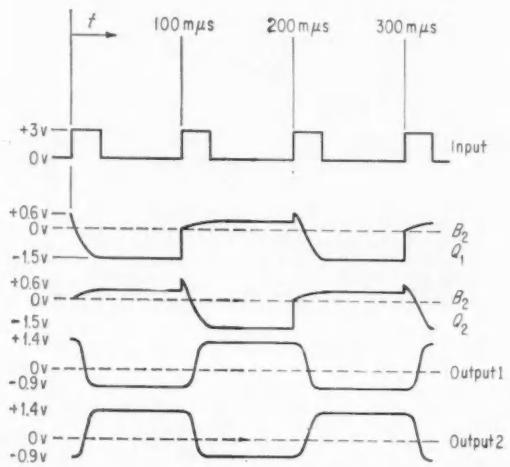


FIG. 5. Waveforms for tetrode flip-flop.

A simple current-mode switching circuit is shown in Figure 2A and 2B. In the simple switch (Figure 2A) if the voltage on the base of transistor Q_1 is greater than V_{BN}, current I_N will flow in Q_1. If the voltage is less than V_{BN} the current I_N will flow in Q_2. There is a serious limitation to this circuit's application: coupling cannot be made directly between the two stages because the output waveform varies around $V_{CN} - \frac{1}{2} h_{FB} I_N R_L$ and the input varies around V_{BN}.

Figure 2B shows a circuit in which coupling is accomplished without shifting the dc level from one transistor to the next, made possible by the use of complementary transistors. In this example, $V_{BP} = V_{CN} - \frac{1}{2} h_{FB} I_N R_L$.

The current-mode flip-flop of Figure 3A is a high speed circuit with only one type of transistor, but it is expensive. The four transistors per flip-flop double the cost of the circuit. In this design, zener diode and two current sources shift the dc level of the output of each transistor.

TETRODE FLIP-FLOP

Although transistors Q_3 and Q_4 (in Figure 3A) are only pullover devices, they must be as fast as Q_1 and Q_2 so that they do not limit the speed of switching. Installation of tetrodes eliminates Q_3 and Q_4, as the circuit of Figure 3B demonstrates. Current sources and batteries have been substituted to make the explanation simpler.

In Figure 3B, assume initially that Q_1 is OFF and Q_2 is ON and the input is from a similar current-mode circuit. The OFF transistor is turned ON in each case. While turning ON, the transistor acts like a tetrode because the second base is negatively biased.

With 3N34 tetrodes, this flip-flop can resolve pulses arriving at a 40-Mc rate. In most applications, however, the flip-flop is required to drive another flip-flop over a range of temperatures. And in a binary counter there has to be a way to steer the input pulses to the correct side.

The flip-flop in Figure 4 is a full temperature range tetrode current-mode circuit that answers the first of these requirements. It can drive another with an input pulse repetition rate of 25 Mc from a fast-rise pulse generator. The steering circuit raises the voltage of the base to be turned ON and puts a negative bias on the one that is ON. When Q_1 is OFF, its base voltage B_2 is 0.6-volt negative. This negative bias makes the current in Q_2 from B_1 to B_2 about 220 microamp.

Higher h_{FE} units in Q_2 will have more tetrode bias and lower ones will have less. When Q_1 turns

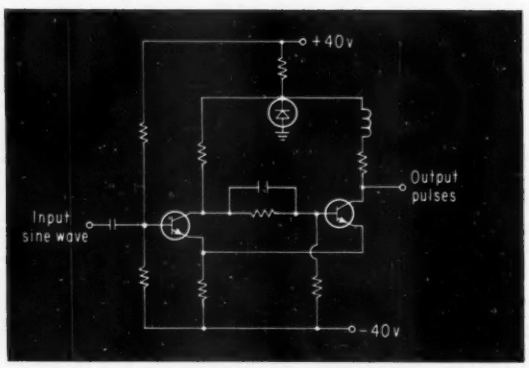


FIG. 6. Schmitt trigger converts input sine wave to pulses for counter.

HIGH-SPEED TETRODE BINARY COUNTER

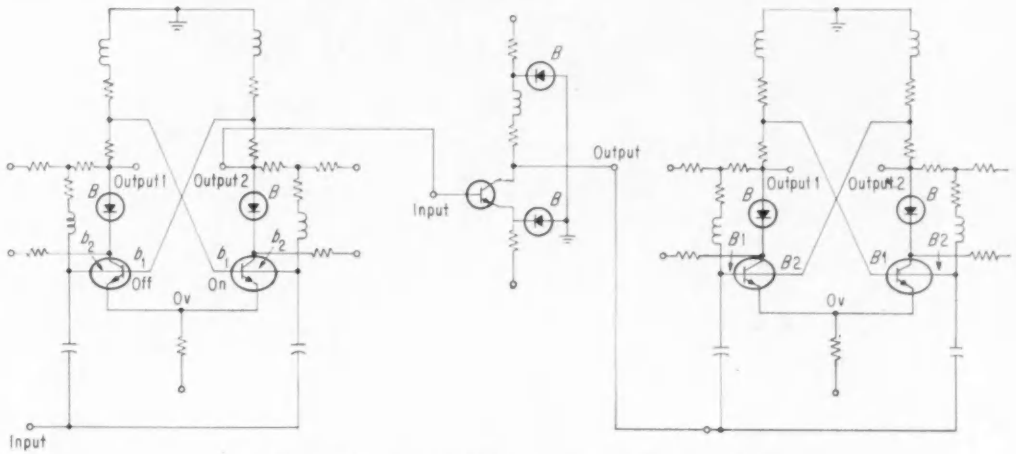


FIG. 7. Current-mode flip-flops and current-mode switches serve as buffers for first two or three stages. Buffer amplifier is a simple current-mode switch in which a fast recovery computer diode replaces a transistor.

ON, its tetrode bias will be 130 microamp. If a positive pulse comes in on both capacitors, it will turn Q_1 ON because that tetrode's second base voltage is at a higher potential. The transistors will then have their conditions reversed: Q_1 will be ON and Q_2 OFF. The next positive pulse will turn Q_2 ON, thus completing the cycle.

Typical waveforms for the flip-flop of Figure 4 are shown in Figure 5. Although the circuit appears unstable with 0.6-volt positive on one base of the OFF transistor, it is actually quite stable because of the impedance. This circuit operates with a 3N34 h_{FE} range of 10 to 130 microamp from minus 55 deg C to plus 85 deg C. As temperature increases the switching speed decreases, so that resolution of input trigger pulses of only 15 Mc is possible at 85 deg C.

BINARY COUNTERS

Above 10 Mc, the generation of pulses is as much of a problem as counting them. A method frequently considered uses high-frequency sine waves. But before a sine wave can be counted with a flip-flop the wave must be shaped into pulses. One circuit that does this is a Schmitt trigger (Figure 6).

The Schmitt trigger supplies output pulses with constant voltage amplitude up to about 20 Mc. It triggers the first stage of the counter at that rate. The sine-wave input voltage required at 20 Mc is 10 volts peak-to-peak and the output is 4.0 volts peak-to-peak. The output can be made greater by increasing the load resistor, but the output transistor must be kept out of saturation. For a counting application the RC time constant of the load is important. The input voltage can be considerably less when counting out speeds.

A complete two-stage binary counter is shown in Figure 7. The output pulse from the second flip-flop, 3 volts peak-to-peak, can drive another buffer stage and trigger another current-mode flip-flop or saturated flip-flop.

When the flip-flop is coupled directly to a similar current-mode circuit, as in a counter, a buffer is needed to trigger the second flip-flop. Because of the inductance in the circuit, the output waveform has some overshoot which could cause a false trigger if coupled through a capacitor. In addition, the output voltage can vary considerably with h_{FE} as the base current increases. Coupling with a capacitor is more reliable if a constant voltage is available.

A good buffer amplifier for such an application is a current-mode switch similar to that of Figure 2A. It has a constant output voltage, its input is directly coupled to the driving flip-flop, and its output is capacitively coupled to the flip-flop to be triggered.

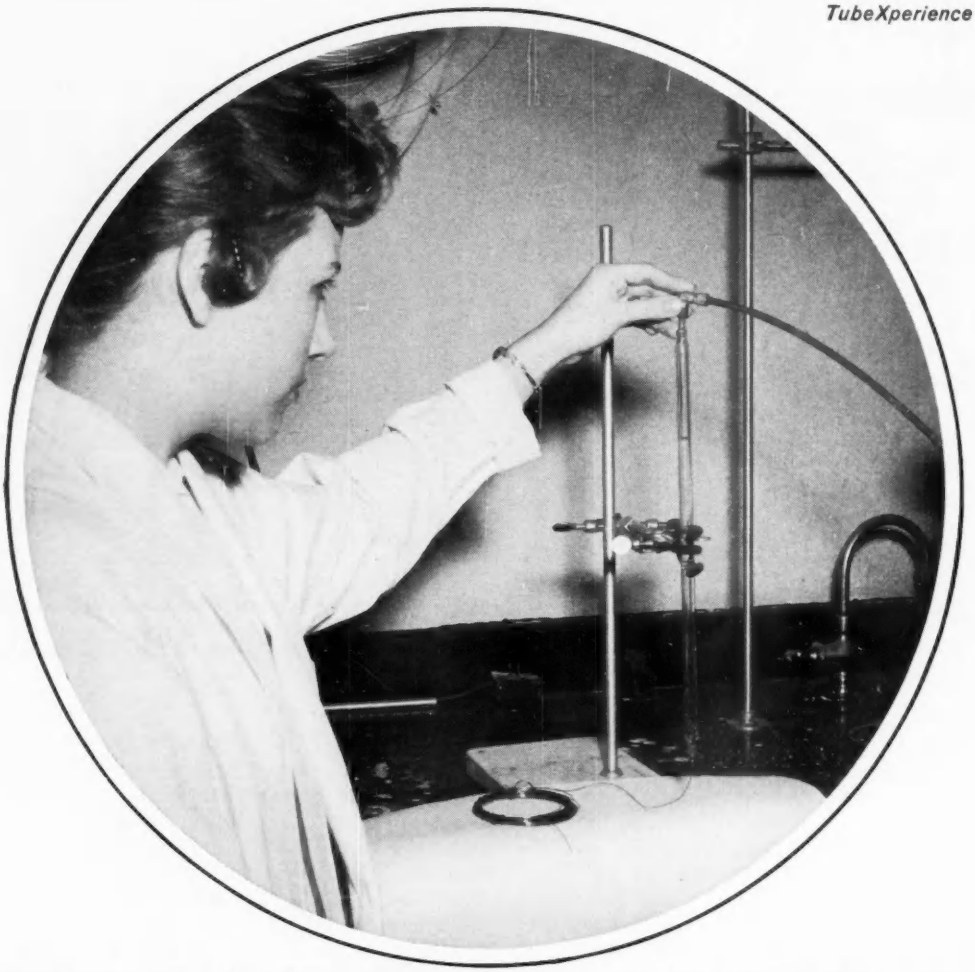
The high speed (20 Mc) binary counter of Figure 7 has current-mode flip-flops and current-mode switches as buffers for the first two or three stages. For the lower frequency stages saturating flip-flops are used.

The buffer amplifier circuit actually in the counter differs from that in Figure 2A in that a diode, D_1, has been substituted for the transistor Q_2 of Figure 2A. D_1, a fast recovery computer diode, acts the same as Q_2 without having a second output.

REFERENCE

A JUNCTION TRANSISTOR TETRODE FOR HIGH FREQUENCY USE, R. L. Wallace, Jr., L. G. Schimpf, E. Dickten, "Proceedings of the IRE", Vol. 40, Nov. 1952, p. 1,395.

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FIG. 1.



Summing Register Forms Core of Numerical System

New incremental point-to-point positioning system has unusual bidirectional decimal summing register as its basic element. Modular approach permits special designs with minimum engineering. Here's how the system works.

L. W. GILBERT
Electronics Div.
Rheem Manufacturing Co.

The Rheem numerical control system is basically an incremental point-to-point positioning system of the on-off type using straight decimal code for dimensional information. As many as five axes may be controlled either simultaneously or sequentially with the basic system. System resolution can be either 0.001 or 0.0001 in. with only nominal differences in the electronics. The feedback transducer is a bidirectional pulse generator that yields 500 pulses per revolution. The transducers can be attached to ball-bearing leadscrews or to precision racks.

The most interesting portion of the system is the bidirectional decimal summing register, shown pulled out from the console in Figure 1. To understand its function, the over-all system must first be examined. (Operator modes and data input requirements are given in Figure 2 and associated text.)

Sequence control

The system block diagram of Figure 3 shows one axis of the control. All control elements except the tape reader, distributor, and sequence control are repeated for the other axes.

The sequence control divides the system into two basic operating phases: the read phase and the machine phase. When the end-of-block signal appears after a block of tape has been read (Figure 2), the sequence control stops the tape reader and switches from the read phase to machine phase. The machine-phase start signal arms the creep and move relays (provided a direction command exists) and axis movement ensues. When the machine element reaches the programmed position, the move relay is deenergized and a coincidence signal appears at the sequence control. When all axes have reached coincidence, the sequence control switches from machine phase back to read phase and the cycle is repeated for every block programmed on the tape. An end-of-tape signal prevents the sequence control from entering the read phase again.

At the beginning of the read phase a tape-start signal is sent to the summing register to clear any spurious counts and to inhibit the borrow and carry function. The counter must be inhibited during the read phase because decimal information is entered into each decade in parallel. At the end of the read phase a tape stop signal is transmitted to the summing register to free the counter for the machine phase.

Bidirectional decimal summing register

During the read phase each decade of the summing register receives decimal information in parallel from the electronic distributor. This programmed dimension represents the incremental distance to the next slide position, and is momentarily displayed in the decimal counting tubes prior to the machine start phase. During the machine phase the register receives pulses from the position transducer which are serially fed into the least significant decade of the bidirectional counter. These pulses return the counter to zero.

The diagram of Figure 4 shows the register in more detail. For the positive direction of motion, signals from heads 1 and 2 of the position transducer are amplified by detector amplifiers 1 and 2 and fed to Schmitt triggers 1 and 2. Direction switching in the detector amplifier circuits causes these signals to be fed to the opposite Schmitt triggers for the negative direction of motion. This is a basic requirement of count down systems since the transducer is direction sensitive.

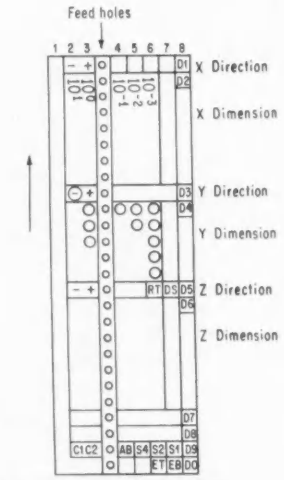
The square wave outputs of the Schmitt triggers are fed to a simple direction gate composed of diodes and passive elements. Depending on the sequence of pulses received from the Schmitt triggers, either the *up* one-shot or the *down* one-shot controls the least significant decade of the counter. Except for perturbations of the output, such as might occur during rapid deceleration, the *down* one-shot always controls during the machine phase.

In turn, an *up-down* gate is controlled by a direction flip-flop which is slaved to the one-shot outputs. The up and down outputs of this gate are connected to all decade amplifiers which also receive cathode inputs *K*0 and *K*9 from the next least significant decade. In this manner all decades are slaved to the least significant decade and count either up or down as required.

In an incremental count down system of the on-off type (where the output runs at one of a variety of fixed speeds), the inputs to the register output gates have fixed values independent of the programmed dimension. It is especially convenient in a decimal system to select any one of the 10 cathodes in each decade to give the exact value of anticipation desired for creep and stop. In Figure 4 the cathodes selected give a creep anticipation of 0.159 in. and a stop anticipation of 0.001 in. These values vary with the application, depending on positioning speed and the response time of the output element. A third register output can also be used if two creep speeds are required.

During the read phase the tape start signal in-

The System From a User's Viewpoint



Symbol	Description
D1-D0	Distributor position
RT	Rapid traverse
DS	Dwell select
C1	Coolant on
C2	Coolant off
AB	Air blast
S1-S4	Spindle selection
ET	End of tape
EB	End of block

FIG. 2. Three-axis input tape system.

The building block principle is used to give flexibility in a variety of industrial control applications. Each axis of electronic control is completely packaged in a separate unit (except for power output elements). Machine sequencing and output control are mechanized with relays, usually on an axis basis, to meet the requirements of a particular machine and its positioning elements. Two power supplies are required per system, one each for the electronic and relay sections. Provision is made for auxiliary functions, which are stored in relays.

Three control modes are available to the operator: automatic, semiautomatic, and manual. The automatic mode provides for completely automatic operation for an entire part or program. The semiautomatic mode provides single block operation, useful for checking new tapes and for maintenance purposes. The manual mode permits operator control of positioning through selector switches for single piece and setup situations.

Data Input

The input medium is standard 1-in. eight-channel perforated tape, read by a 100-line-per-sec photoelectric tape reader. It takes about 0.20 sec to read an average block length for a three-axis machine. Since the system uses the decimal code from the part drawing to the display of programmed position, dimensional information is punched in straight decimal.

The format for a 0.001-in.-resolution, three-axis system is shown in Figure 2. In a 0.0001-in.-resolution control, column 7 would be used for the least significant decade (10^{-4}). In all systems the feed hole represents the decimal point, facilitating visual interpretation. The magnitude of the programmed move is equivalent to the sum of the holes punched in each column or decade; the example shows a 3.125-in. move in the Y axis.

Column 8 is used for distributor control. Only two distributor positions are required for each axis or word. Positions D1, D3 and D5 are used for programming direction, positions D2, D4, and D6 for dimensional information. Distributor positions D7, D8, D9, and D0 may be used for auxiliary functions or additional axes.

Both word length and block length are variable. Word length depends on the magnitude of the largest digit (number of holes in a column), whereas block length is a function of the number of axes with programmed moves.

The input unit distributes tape information to the dimension registers and relay section through an electronic distributor. No stepping switches are used. Dimensional information for one axis, entered into the register in parallel, is distributed through one distributor position.

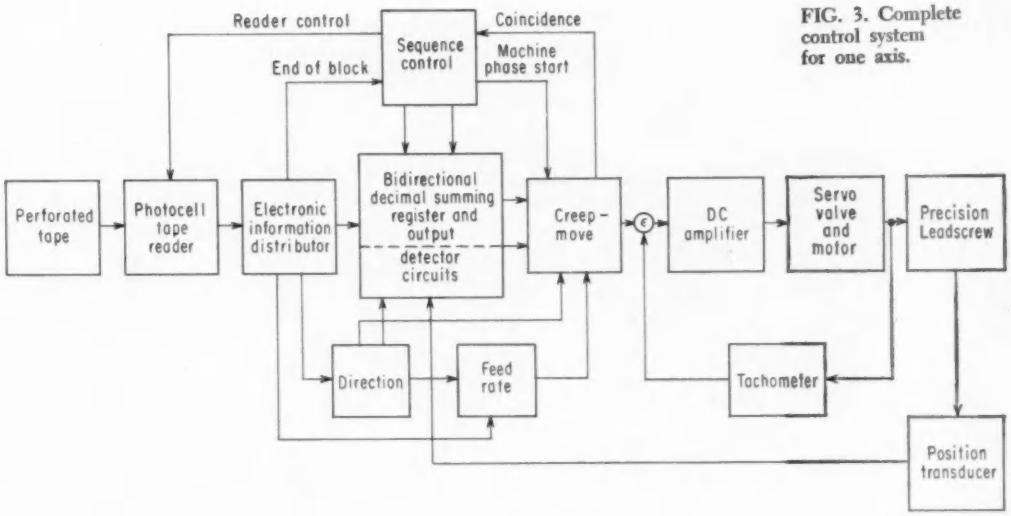


FIG. 3. Complete control system for one axis.

hibits the borrow and carry function of the counter and clears the register. Then the information coded on the tape is fed to each decade of the counter in parallel. The least significant decade is loaded through the up one-shot and the other decades through the corresponding decade amplifiers. Then with the desired distance to be moved stored in the register, the machine phase proceeds as described above, and counts the register down.

A third sensing head on the position transducer (zero head) detects each complete revolution of the transducer shaft. The signal from this head, in conjunction with a signal from a limit switch operated by the machine slide, gives a precise indication of machine zero or a reference position. When the zero is actuated, the counter is inhibited by the zero (or counter-inhibit) flip-flop. As the machine slide moves to open the zero switch, the counter is enabled by the next pulse from the zero head.

Output Control

The output control provides the relays and associated drive elements required for the axis drive units. As shown in Figure 3 the basic functions are direction, creep, move, machine zero (not shown), and feed rate (when used). These controls will vary somewhat with the application and type of drive system (electrical or hydraulic).

The arrangement of Figure 3 uses a hydraulic drive system with a servo valve and motor and tachometer feedback. Feed rate is generated in a binary controlled resistor network that yields a voltage proportional to the desired output. Where feed rate control is not required, the control elements of the rate loop can be replaced by solenoid valves, electric clutches, or other on-off devices.

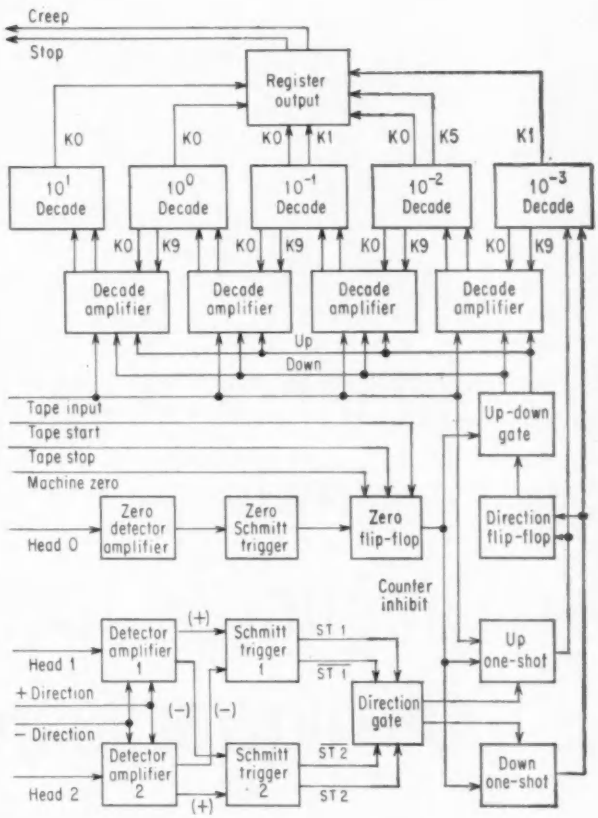
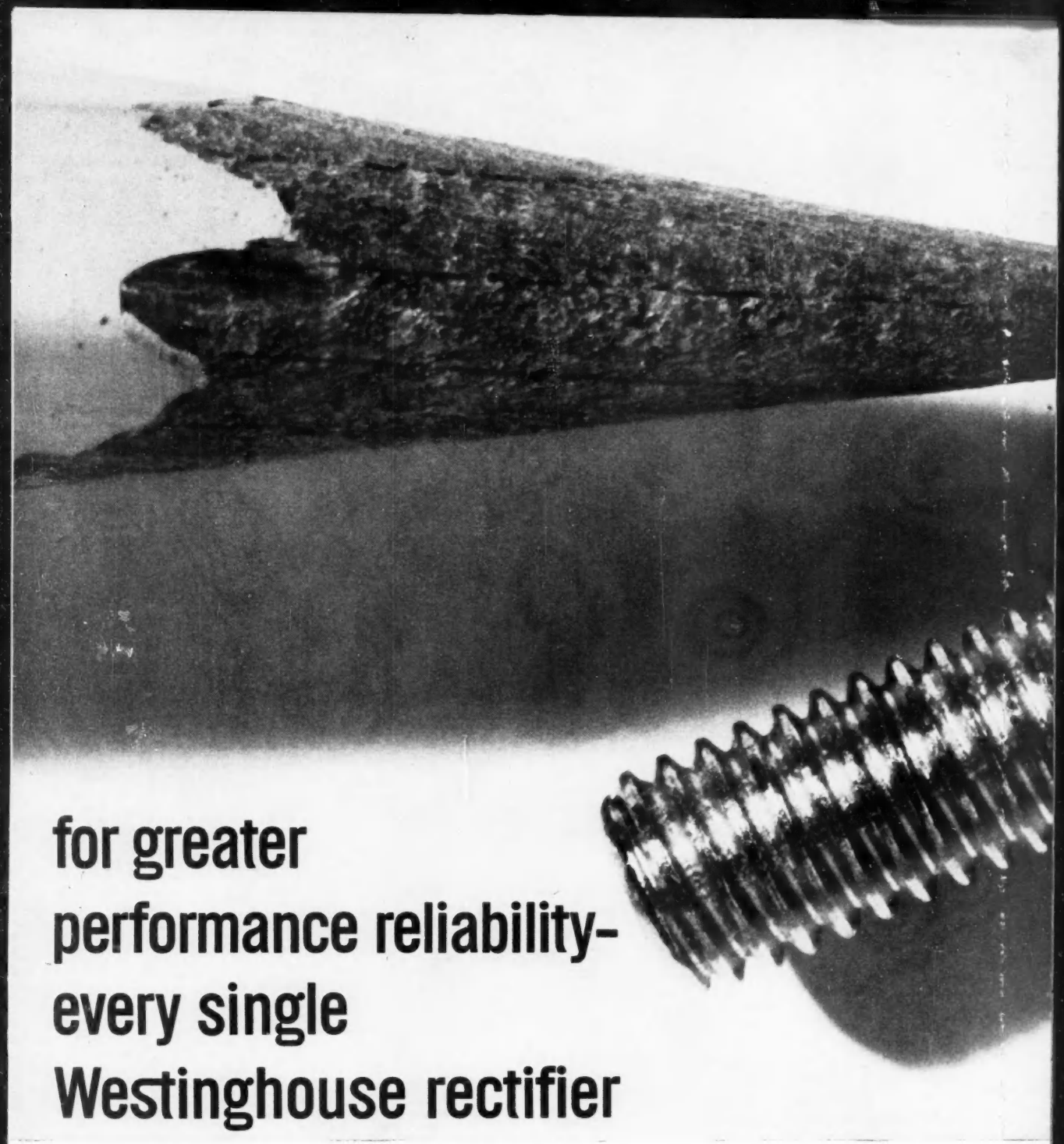


FIG. 4. Bidirectional decimal summing register.

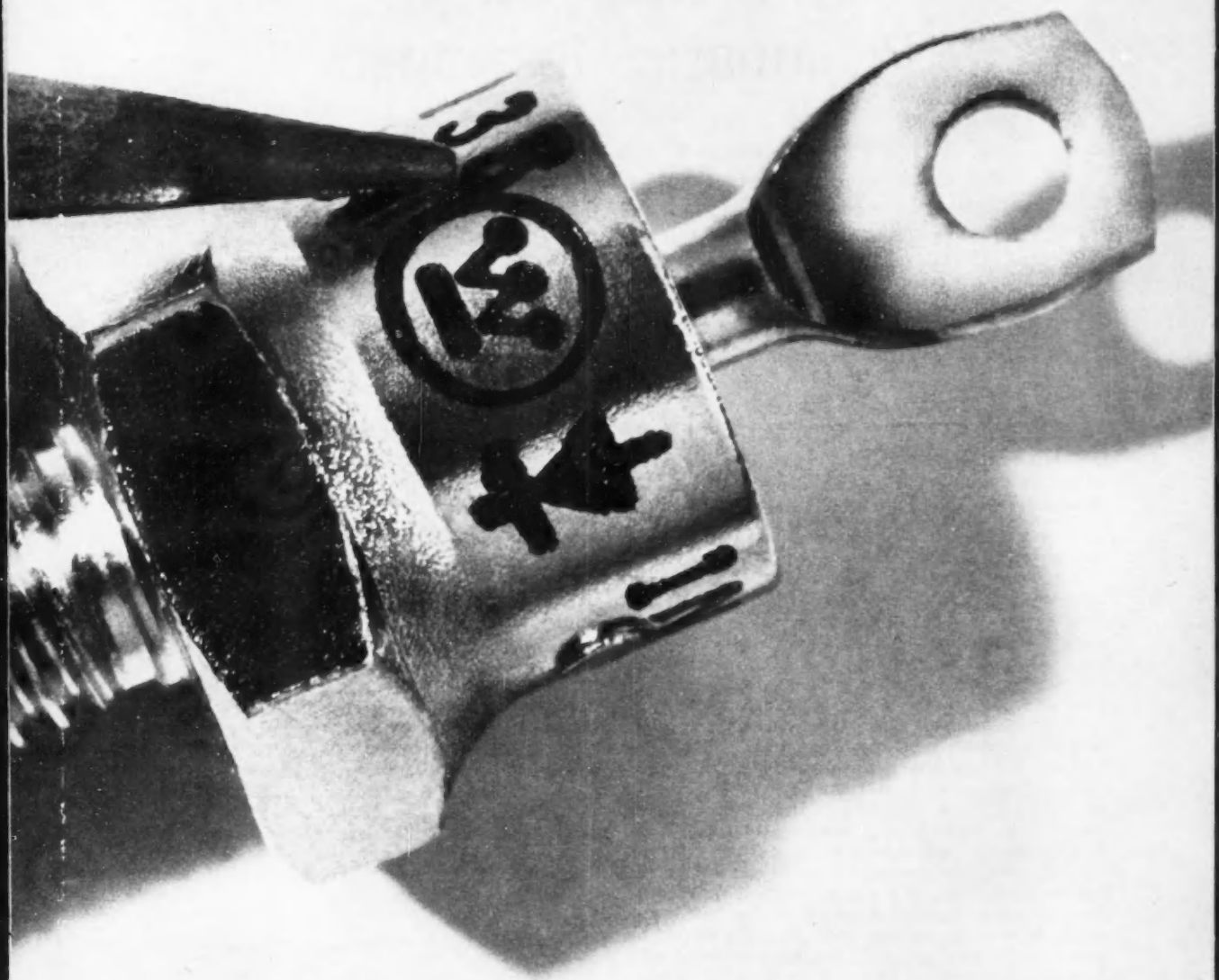


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CIRCLE 127 ON READER SERVICE CARD

How Dials Direct Pneumatic Messengers

THE GIST: This air powered data transmission system speeds up to 2,400 carriers an hour between 65 stations. The carriers themselves are not programmed in any way; all the operator does is dial the number of the distant station on a wall telephone dial. As many as 175 carriers can move through the system simultaneously, with electromechanical control circuits assuring that each arrives at its destination in less than a minute. Completely self-supervised, the system has just been installed in one of New York City's newest and most modern buildings.

GERHARD TODT
Airmatic Systems Corp., an associate of International Telephone and Telegraph Corp.

A pneumatic tube system was the obvious way to transport interoffice documents in the First National City Bank's new uptown headquarters in New York City. The problem was one of capacity, since the bank wanted a high traffic density system that would connect offices on every level from the third sub-basement to the 41st floor. Using telephone dial and switching techniques, Airmatic Systems Corp. met this need with the world's busiest automatic tube system.

Carriers 5 15/16 x 2 1/16 in. (oval) x 14 in. carry all types of papers, mail, and punched cards through about 10,000 ft of 4 x 7 in. O.D. tubing. There are now 65 sending and receiving stations, and 15 more can be added at any time. A carrier can be sent from any station to any other station in less than a minute. In a control room on the fourth floor an electromechanical copy of the tube network, Figure 1, controls traffic, and lights on a supervisory panel indicate the position of every carrier in the system. As each carrier moves along, its destination mark is transferred from one telephone-type relay memory to another so that carrier and destination keep in step. Tube contacts maintain synchronization and tell the circuitry when and where it can let new carriers into the network.

In a system this size it would be out of the question to have pairs of sending and receiving lines connecting every station with every other station. Instead, nine sending and eleven receiving lines are connected by central transfer points (CPT's). Each line serves up to ten stations. A carrier coming into a CTP on any sending line can be switched into any receiving line by electromechanical deflectors in the CTP. If a carrier is bound for a receiving line not serviced by that CTP, it is routed into a trunk line that carries it up to the top of the other CTP.

To send a carrier, one opens a door on the station front, drops in the carrier, and lets the door shut. If the operator forgets to snap the carrier end flap closed, the door takes care of this; if he puts the carrier in tail first, the door won't shut completely and the carrier can't be sent. With the carrier in place, a yellow light flashes on the station panel. The operator then dials the two-digit number of the destination. After dialing, he has 6 sec to recognize an error and hit a correction button. After this interval, the carrier goes if the line can receive it.

Lines are divided into as many as three zones called near, middle, and far (from the CTP), Figure 2. Zone boundaries are defined by electromechanical contacts called inlet and outlet contacts (IC's and OC's) which are connected to a zone control. This control counts carriers coming into the zone, accepts carriers from senders in that zone if the line is clear, and passes along destination information as the carrier progresses through the line.

Suppose, for example, that a carrier is dispatched

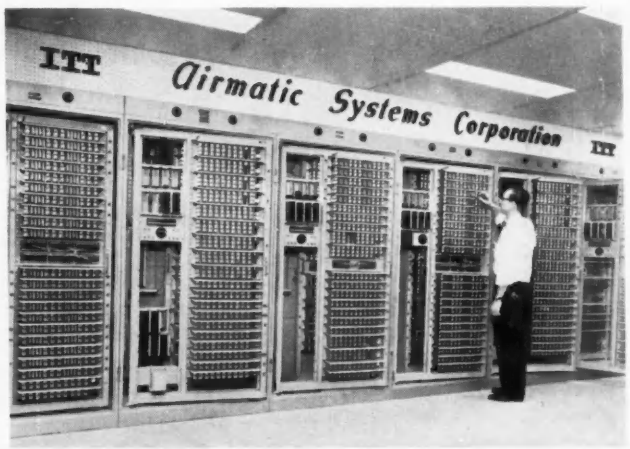


FIG. 1. Telephone-type circuits store destinations and control traffic.

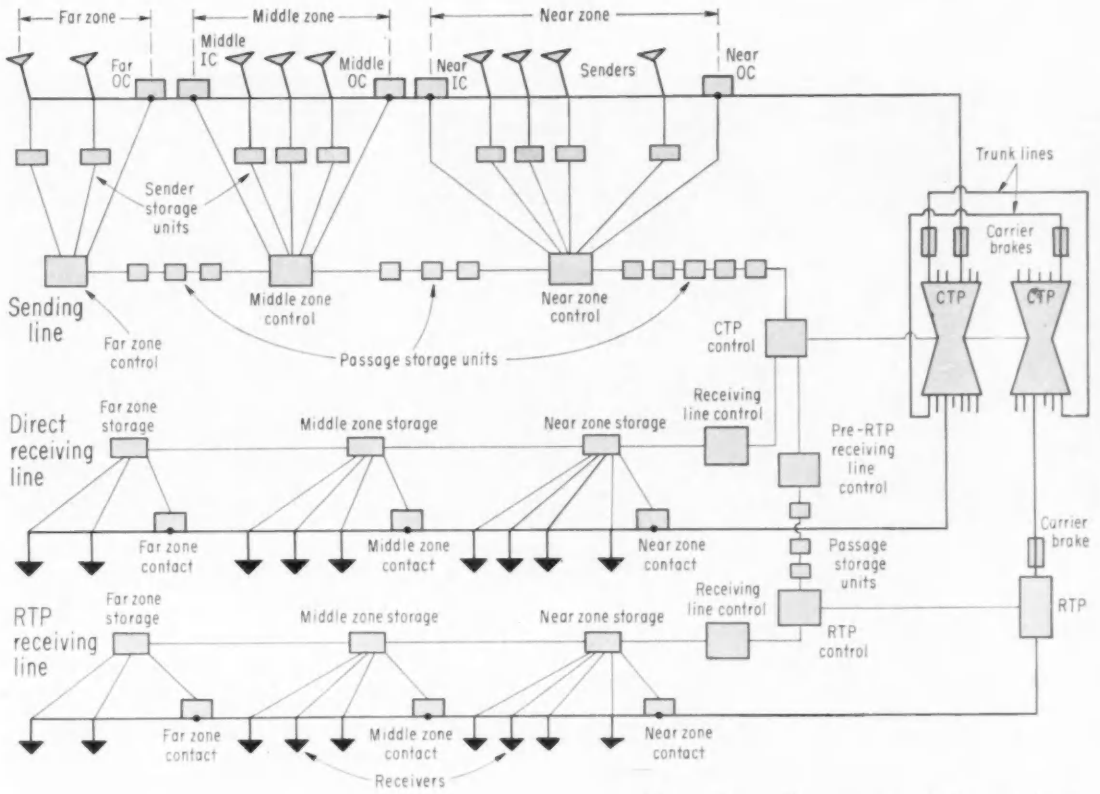


FIG. 2. Heavy lines are pneumatic network; lighter ones the electromechanical control system.

from a station in the far zone of the sending line in Figure 2. As the carrier's destination is dialed, this information is stored in the storage unit for that sender. Far zone control then determines whether there are any carriers already in the line that have not cleared far zone OC. If so, it holds the new carrier in its sender; if not, it releases the carrier into the line. As soon as the new carrier passes far zone OC, far zone control transfers its destination mark to a passage storage unit and accepts any carriers waiting in far zone senders in the order their destinations were dialed.

Meanwhile, middle zone control has been accepting carriers from its senders, but as soon as a carrier from the far zone passes the middle zone inlet contact, any carriers waiting in middle zone senders are held there. The far zone carrier then proceeds through the middle zone, and when it crosses the middle zone outlet contact its destination mark is transferred to a passage storage unit following middle zone control. Now middle zone control can accept middle zone carriers again unless another carrier from the far zone has passed middle zone IC.

In like manner, the far zone carrier passes through the near zone while near zone control holds near zone carriers in their senders until the carrier clears near zone OC. While passing through zones and intervening tubing, carriers must not ride head to tail because two carriers would then actuate inlet and outlet contacts only once. The stations and contacts are laid out so that one carrier can never catch another in this part of the system. After passing near zone OC, however, the carriers can and do bunch up on their way to the central transfer point. Just before reaching the CTP, the carriers are halted by a carrier brake—a slowly moving belt on one side of the channel through which the carriers fall into the CTP. Normally, the CTP accepts carriers in the order they arrive, but as soon as five carriers are lined up above the CTP in any one line, that line gets priority. As each carrier enters the CTP, CTP control reads its destination mark from the last passage storage unit. The first digit tells the CTP which receiving line to switch the carrier into; the second digit indicates the correct station in that line, and this information is passed along to the proper receiving line control.

There are two types of receiving lines—direct lines, and those with a remote transfer point (RTP). Assume first that the carrier is going to a near zone station in the direct receiving line of Figure 2. As soon as the carrier crosses the near zone contact, receiving control for that line passes its station number along to near zone storage and releases another carrier from the central transfer point *if* it is bound for a near zone station. Meanwhile, near zone storage operates a deflector that delivers the first carrier to the correct station. As the carrier passes through, the deflector shuts automatically. Whenever a carrier crosses the middle zone contact, the CTP can release a carrier bound for either the

HOW CARRIERS ARE SENT . . .



FIG. 3. Loaded carrier is put in airtight compartment.



FIG. 4. Dialing two digits, clerk sends the carrier on its way.

. . . AND DELIVERED.



FIG. 5. Heavy mail room traffic requires two receiving devices.

near or middle zones; when a carrier crosses the far zone contact, a carrier headed anywhere in the line can be released. This way, as many as three carriers can be in the line at once with no danger of any of them going to the wrong station. To prevent carriers from catching up with one another, each zone contact is placed 60 percent of the way from the CTP to the farthest station in that zone.

Remote transfer point receiving lines are used where traffic density is extra high and it is necessary to get carriers into the line in a hurry so they won't pile up above the CTP. Like CTP's, each RTP has a carrier brake and can halt carriers until the receiving line beyond is able to accept them. When a carrier is sent into an RTP line, its station number is read into the pre-RTP control for that line and then held in passage storage units until the carrier is released by the RTP. The rest of the line is just like the direct line described above. Station numbers go to receiving line control, and the zone storage units actuate station deflectors as required.

As each carrier passes through the network, its progress—from sender to receiver—can be observed as blinking lights on the control room board. Counters in the zone controls continuously compare the number of carriers in each zone with the number of destination marks in the electrical system. Any discrepancy shows red on the board, and the trouble area is selectively protected against incoming carriers, leaving the rest of the system completely operative. After a recycling period to clear carriers and destination marks from the system, normal operation is restored, and only if a stoppage persists do the affected stations stay locked up. The board lights then tell the maintenance men where to look for trouble. The system will also respond instantly to any foreign matter in the tubing that could tie up traffic. The maintenance engineer can also lock out any sending or receiving stations or any part of the network for overhaul, repair, or expansion, simply by inserting a control plug into a control room panel.

Another unit in the control room is a sending and receiving station, not used under normal conditions. This station receives and can redispatch carriers that have been dialed to stations temporarily out of service, either because a department is not in operation at the time or for any mechanical reasons. Without this safety station, carriers for non-operative stations would either stay in the system, tying up operation, or they would go to another station. The safety station also doubles for redistribution of carriers needed in a department and gives the maintenance engineer complete test facilities.

Three compressors of 75, 40, and 10 hp provide the vacuum that sucks carriers through the system. Station and contact spacings are based on a carrier speed of 25 ft per sec along horizontal runs and up to 40 ft per sec on vertical drops. These speeds are based in turn on a design carrier weight of 2.2 lbs. Safety factors generally keep things moving even when mail room workers jam 8 or 9 lbs of envelopes into the carriers during the morning rush, but to prevent the system from ever stalling, the air speed in each line is measured continuously. Whenever it drops below a critical value, the sending stations in that line are locked automatically until the traffic then in the line is delivered.

Most of the specially designed stations receive carriers in airtight compartments with doors (below the dial in Figures 3 and 4). A red light shows when a carrier has arrived in the compartment. Some heavy traffic stations like the mail room, Figure 5, have two sending and receiving devices and receive carriers onto tables and into bins.

By means of double sending and receiving stations, zone control in the lines, remote transfer points, high speed central transfer points, and complete self-supervision of traffic, the traffic capacity of the system was raised to 2,400 carriers per hour (one carrier every 1.5 sec), giving this tube system the highest capacity of any in the world.

Are Your Computers Protected Against Fire?

If you have a major process or an important portion of your business operations under direct control by an electronic computer, a fire in the computer area could put you out of business. Much has been written on the systems planning required before installing a computer, but the vital consideration of fire protection has been sadly neglected. Here are some recommendations from the National Fire Protection Association.



United Press International photo.

FIG. 1. The Air Force's statistical computer center after the Pentagon fire on June 2, 1959. Equipment and property loss: $7 million. Pentagon fire safety is the responsibility of the General Services Administration.

The lack of consideration given to the prevention of loss by fire in most electronic computer installations was made forcefully clear by the fire that destroyed the Air Force's statistical computer center in the Pentagon on July 2, 1959. The equipment and property lost in that fire was later valued at nearly $7 million. But the cost of replacing the vital data on magnetic tapes and other records that were destroyed raised the total loss to an estimated $30 million. The value to national defense of irreplaceable records and the unavailablity of other records during replacement is inestimable.

The Pentagon fire precipitated the formation of a Committee on Electronic Computer Systems within the National Fire Protection Association—an association of 18,000 individuals and 200 organizations that originates and maintains such definitive standards for fire prevention as the National Electrical Code. Last month NFPA Annual Meeting received a proposed tentative standard prepared by this committee for the protection of electronic computer systems (NFPA No. 75-T). The membership of the committee represents all types of parties interested in this problem.

A tentative standard must be resubmitted for final adoption in a year's time. Even final NFPA codes can be legally binding only if adopted as part of local ordinances by legal authorities. Further, compliance with these codes must be considered a means of self-insurance to keep a business going—premiums on purchased insurance are not usually reduced for following an accepted code.

Standard sets minimum requirements

The stated purpose of tentative standard 75-T ". . . is to set forth the minimum requirements for the protection of electronic computer systems from damage by fire or associated effects." The scope of the tentative standard is described as ". . . intended to cover installations specifically designed for electronic computer equipment covering computer room, building construction, and utility requirements. It also sets forth recommended fire protection features for the construction and protection of electronic computer system components, associated records, and emergency procedures . . ."

The order in which these topics are taken up by the standard is as listed above, except that the part on utility requirements follows that on the protection of records. The sequence of topics in the standard itself is eminently reasonable from the standpoint of those considering new computer installations. In this article, however, the topics have been rearranged to emphasize the recommendations likely to be immediately useful to persons already operating an installed computer.

Excerpts from the Computer Protection Standard

The definitions and recommendations that follow are excerpted directly from NFPA Tentative Standard No. 75-T and are quoted directly except as indicated by brackets. The sequence of topics has been changed for the reasons described above. The complete tentative standard can be obtained by writing Mr. George H. Tryon, Technical Secretary, National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass. NFPA welcomes comments and suggestions from Control Engineering readers on the recommendations made by the standard as reported here.

PROTECTION OF RECORDS

Value of records. The evaluation of records should be a joint effort of all parties concerned with the safeguarding of computer operations. The amount of protection provided for records shall be directly related to the importance of the records as measured by evaluation of what the loss of a particular record would mean in terms of the mission of the computer system and the re-establishment of operations after a fire. In order to maintain a reasonable sense of consistency, it is assumed that computer equipment capable of properly using the records will be available. The following classifications of records are based on the recommendations of NFPA No. 232, Protection of Records. All records shall be evaluated and assigned to one of these categories to ensure that adequate protection is provided where necessary and that unimportant records are not overprotected.

Vital records—Records that are essential to the mission, are irreplaceable, or would be needed immediately after the fire and could not be quickly reproduced. Examples might include vital programs, master records, equipment wiring diagrams, and certain input-output and memory data.

Important records—Records that are essential or important but which, with difficulty or extra expense, could be reproduced without a critical delay of any essential mission. Some programs, wiring diagrams, memory and input-output data have this level of importance.

Useful records—Records whose loss might occasion much inconvenience but which could easily be replaced and which would not be an insurmountable obstacle to prompt restoration of operations. Programs and procedures saved as examples of special problems are typical of records in this category.

Nonessential records—Those records which on examination are found to be no longer necessary.

Protection required.

Records kept within the computer room. a) The amount of records kept within the computer room shall be kept to the absolute minimum required for efficient operation. Nonessential records shall not be kept in the computer room. b) Any records regularly kept or stored in the computer room shall be provided with the following protection:

1) Vital or important records shall be stored in Class D or better records protection equipment except that punched cards may be stored in standard metal drawer files.

2) Useful records on paper based or plastic materials shall be stored in metal files or cabinets.

3) Useful records on metal based material require no special protection.

Records stored outside of the computer room. a) To the maximum extent consistent with efficient operation, all record storage shall be outside of the computer room.

b) Records storage room.

1) Vital and important records shall be stored in fire-resistive rooms or vaults. The degree of fire resistance shall be . . . not less than two hours.

2) Unless the records are contained in metal files, cabinets or other noncombustible containers, records storage vaults or rooms shall also be provided with automatic sprinkler or other suitable installed fire-extinguishing systems.

3) Useful and nonessential records do not require any special fire protection unless these records are stored with vital or important records. In such case the requirements for the most valuable records apply to all records.

4) The records storage room shall be used only for the storage of records and unused record media. All other operations including splicing, repairing, reproducing, etc. shall be prohibited in this room.

When records are kept in cases, boxes or other containers, protection shall be that required for the highest level of damageable media in the total assembly of records and containers.

Duplication of records. The best protection for records consists of storing duplicate records in separate areas not subject to the same fire. The keeping of duplicate records is particularly important when records on magnetic tape are involved. The degree of resistance of magnetic tape to fire exposure is not completely known. It is known, however, that fire exposures (heat and/or steam) that would not damage records on paper media may damage records on magnetic tape. The protection of records on magnetic tape by storage methods presently available [is] limited.

a) Vital records on magnetic tape shall be duplicated (on magnetic tape or other media) and the duplicates stored in an area which is not subject to a fire that may involve the originals, preferably in a separate building.

b) A duplicate copy shall be made and maintained of any vital record which is regularly kept or stored in the computer room. This duplicate may be on the same or different media and shall be kept . . . outside of the computer room.

c) Whenever practical, other vital and important records shall be similarly duplicated and stored.

Protection against building collapse. In any building where a fire may result in a building collapse which could either drop the records storage equip-

ment or drop structural members on the records storage equipment, the records storage equipment shall be of types designed to protect the records against damage from the impact involved.

FIRE EMERGENCY PROCEDURES

Preplanning for continued operation in a fire emergency. The continued operation of an electronic computer system is dependent on information stored on cards, tape, discs, drums, etc. Therefore, the preplanning . . . should include:

a) A program to protect records in accordance with their importance as set forth by the section on protection of records.

b) Arrangements for emergency use of other installed computer equipment to cover:

1) Plans for transportation of personnel, data and supplies to emergency computer locations.

2) Agreements and procedures for the emergency use of the computer equipment.

c) Programs designed with adequate number of checkpoints and restarts to ensure rapid recovery.

Emergency fire procedure. A written emergency fire plan shall be prepared for each installation which assigns specific responsibilities to designated personnel. The following major items are suggested as minimum features of this plan.

Remove all power to the computer system. a) Means —main line circuit breaker or equivalent for turning off all power. b) Location of control for disconnecting means—remote controls for operating the disconnect located near the operator's console and next to the main exit door.

Shut down air conditioning system. c) In case of completely separate systems only. Emergency means similar to that described [under a) Means should be] provided to turn off the computer room air conditioning. They should also be located near the emergency power shut-off device. d) In cases of regular building systems only. Emergency means similar to that described [under a) Means should be] provided to close off all duct dampers leading to and from the computer room. They should be located near the emergency power shut-off device. e) In cases of combining the regular building system with a supplement system. Emergency means provided to simultaneously accomplish the similar action . . . in the preceding c) and d) items.

Notification of proper authority. f) Building fire brigade. Fire brigades shall be called immediately. g) Outside fire-fighting company. Outside fire departments shall be called in accordance with the emergency fire plan.

Damage control. Means should be provided to prevent water damage to electronic equipment. The proper method of doing this will vary according to individual equipment design. Consideration should be given to the provision of waterproof covers.

PROTECTION OF COMPUTER ROOMS AND EQUIPMENT

Protection of computer rooms. If the construction of the computer room is of combustible material . . . or the housing structure is combustible, the computer room shall be protected by an automatic sprinkler system.

Automatic sprinkler systems protecting computer rooms or computer areas shall conform to NFPA Standard for the Installation of Sprinkler Systems (No. 13). Sprinkler systems protecting computer rooms may be valved separately from other sprinkler systems.

To minimize water damage to the electronic computer equipment located in sprinkler protected areas, it is important that power be off prior to the application of water on the fire . . . [see Emergency fire procedure.]

Smoke or fire detectors shall be provided in the air space below existing combustible raised floors to sound an audible as well as visual alarm and to shut down all electric power passing through the air space.

Portable fire extinguishers. Approved portable carbon dioxide extinguishers shall be provided and maintained for electrical fires (see NFPA Standard for the Installation, Maintenance and Use of Portable Fire Extinguishers, No. 10).

Approved Class A type extinguishers shall be provided and maintained for ordinary combustible materials such as paper.

Training. Designated persons working in the computer area shall be thoroughly trained in how to use each of the available types of manually operated fire-fighting equipment, their capabilities and their limitations.

Types of computer equipment. [from section of standard on Construction of Computer Equipments.]

Type I—So designed that when de-energized, fire will be confined to the immediate area or component where the source of ignition is located, to the extent that the affected parts can be readily replaced. The equipment shall include automatic means to de-energize the circuits when components or units are caused to operate at or to be subjected to temperature above normal operating conditions.

Type II—So designed that fire will not spread beyond the external housing of the unit in which the source of ignition is located.

Type III—Includes all equipment not defined in Types I and II above.

Protection requirements for equipment. In addition to the protection required elsewhere in this standard, each unit of an electronic computer system shall be provided with the following special protection:

Type I equipment. Type I equipment requires no special protection.

Type II equipment. There shall be available to each unit of Type II equipment . . .

a) Carbon dioxide fire extinguishers or . . . hand hose systems installed in accordance with NFPA Standard for Carbon Dioxide Extinguishing Systems, No. 12, shall be considered as providing adequate extinguishing protection provided . . .:

1) The equipment, during all periods that it is energized, is under supervision of an operator . . . trained in the operation of the types of extinguishers or hand hose systems involved.

2) Adequate controls are readily accessible to shut down power and air conditioning. . . .

3) All interior sections are readily accessible to

manual application of the extinguishing agents.
4) There is located within the computer room and not more than 50 feet from the equipment under consideration either a carbon dioxide fire extinguisher or carbon dioxide hand hose system having a capacity of at least one pound of carbon dioxide for each cubic foot of volume of the unit under consideration if the equipment is on open racks;—one-half pound for each cubic foot of volume if the unit . . . is enclosed in a cabinet.

b) Type II equipment not meeting the requirements of a) above shall be protected by an installed local application . . . extinguishing system. . . .

Type III equipment. Because of the hazard presented by the possibility of communication of fire to other equipment outside of Type III unit, hand applied extinguishing agents shall be considered inadequate except in the case of small (table top or desk size) units. Except for the previously mentioned small units, all Type III equipment shall be protected with a local application carbon dioxide extinguishing system.

GENERAL COMPUTER ROOM REQUIREMENTS

Materials and equipment permitted in the computer room. Except as noted below only the actual electronic computer equipment and such input-output or other auxiliary electronic equipment electronically interconnected with the computer or which must be located in close proximity to the electronic computer equipment shall be permitted within the computer room itself.

a) Metal office furniture. . . . b) Small supervisory offices . . . directly related to the electronic equipment operations . . . if all furnishings are metal. . . . c) Records may be kept in the computer room to the extent allowed [under Protection of Records].

The following shall not be permitted within the computer room: a) Any activity or occupancy not directly associated with the electronic computer system(s) involved. b) Supplies of paper or other combustible material in excess of that necessary for efficient operation. c) Service and repair shops and operations except for that servicing and repairing performed directly on machines which are impractical to remove from the computer room. d) Bulk storage of records. e) Any other combustible material, equipment or operation which constitutes a hazard and which can be removed.

Combination of systems. Separate electronic computer systems should not be combined in a single computer room unless the systems are interconnected electronically, use the same input-output equipment or must be located in the same room for other operational reasons.

BUILDING CONSTRUCTION REQUIREMENTS

Building construction. The computer area shall be housed in a fire-resistive, noncombustible or sprinklered building.

When the portion of a nonfire-resistive structure housing a computer area is a separate fire division, only that portion of the structure housing the computer area is required to comply with [the previous paragraph].

Location of computer area. The electronic computer area shall be located to minimize fire, water, and smoke exposure from adjoining areas. . . .

The computer room shall not be located above, below or adjacent to areas or other structures where hazardous processes are located unless adequate protective features are provided.

Computer room construction. The computer system should be housed in a room of noncombustible construction. . . . All materials including walls, floors, partitions, finish, acoustical treatment, raised floors, raised floor supports, suspended ceilings, and other construction involved in the computer room, shall have a flame-spread rating of 25 or less (see NPFA Standard Methods of Fire Tests of Building Construction and Materials, No. 251). Floor covering materials, such as asphalt, rubber or vinyl floor tiles, linoleum or static-free carpeting may be used to cover any exposed floors. All metal floors shall be grounded in accordance with the NFPA National Electrical Code, No. 70.

In multistoried buildings, the floor above the computer room shall be made reasonably watertight to prevent unnecessary water damage to equipment. Any openings at beams, pipes, etc. shall be sealed to watertightness.

Raised floors (where required). Raised floors including the structural supporting members shall be of concrete, steel, aluminum or other noncombustible material. Pressure impregnated, fire-retardant treated lumber having a flame-spread rating of 25 or less may be used (see NFPA Method of Test of Surface Burning Characteristics of Building Materials, No. 255). Other types of wood construction shall not be used for raised floors. . . .

UTILITIES

Air conditioning systems. Air conditioning equipment shall conform to the requirements of NFPA Standard for Air Conditioning and Ventilating Systems, No. 90A, and to the additional requirements set forth below.

A separate air conditioning system should be provided for the computer area.

If the computer area is within an area which is air conditioned and additional air conditioning capacity is not required, the ducts serving the computer area should have suitable fire dampers, as outlined in NFPA Standard No. 90A.

Air ducts shall not pass through any computer records storage vault or room.

Electrical service. All wiring shall conform to the NFPA National Electrical Code, No. 70.

Service transformers should not be permitted in the electronic computer area.

Protection against lightning surges shall be provided where needed. . . .

The number of junction boxes in underfloor areas should be kept to a minimum.

Emergency power controls. Controls for the disconnecting means [for] the main service wiring supplying [the computer] shall be located near the operator's console and next to the main exit door. . . .

Digital Computer Programs Analog Solutions

To demonstrate the feasibility of automatic setup and operation of an analog computer by a digital computer, the authors programmed a digital computer to list standard analog computing components together with interconnections and gain settings for a general though limited class of differential equations. The printed list is easily translated into an analog computer schematic for the particular problem. Automatic analog computer setup is an easily visualized step that would involve transistor matrix or crossbar switching and servo-set potentiometers. The technique would work well into an analytical analog-digital computer combination, and also into computing control systems where the digital computer is the primary controller but the analog computer is indispensable for speed and simplicity.

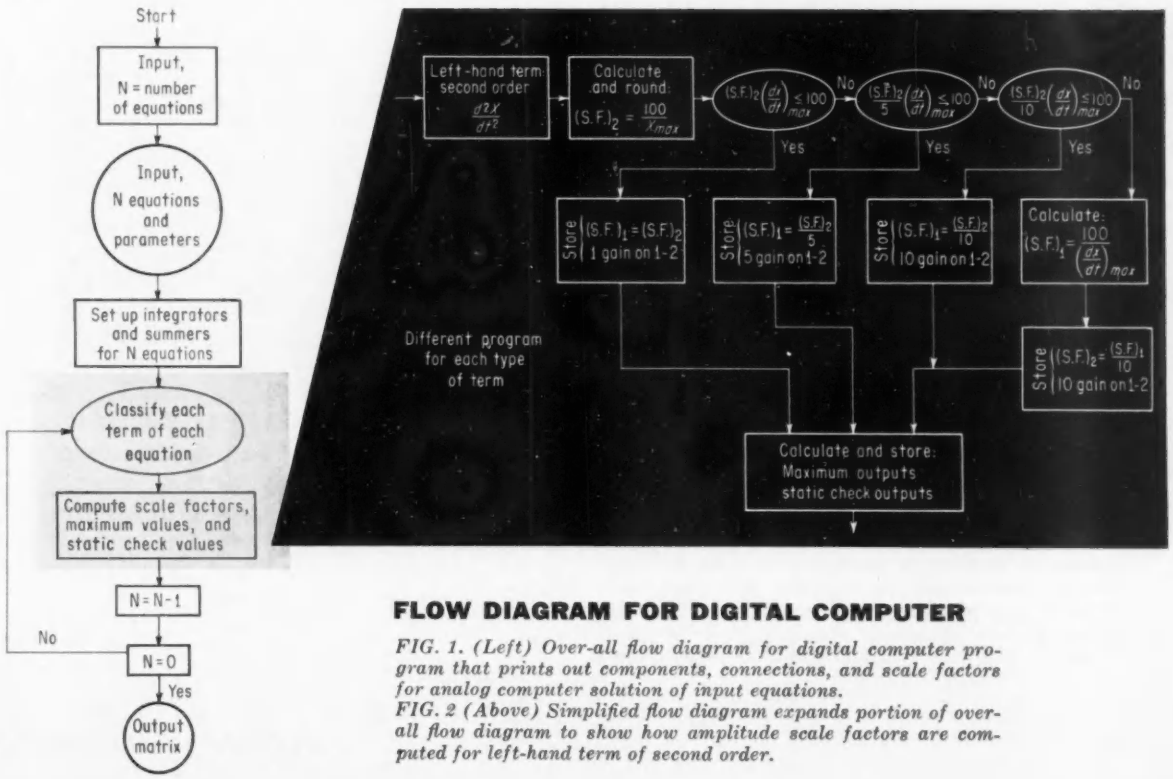
THEODORE H. WITZEL
JANE L. WILSON
Convair Astronautics

A digital computer program has been written to print out an analog computer program that represents any particular solution for linear and nonlinear differential equations of the general form

$$\frac{d^n x}{dt^n} = \pm \text{ (term)} \pm \text{ (term)} \pm \ldots$$

$$\frac{d^m x}{dt^m} = \pm \text{ (term)} \pm \text{ (term)} \pm \ldots$$

The present digital program is limited to terms of



FLOW DIAGRAM FOR DIGITAL COMPUTER

FIG. 1. (Left) Over-all flow diagram for digital computer program that prints out components, connections, and scale factors for analog computer solution of input equations.
FIG. 2 (Above) Simplified flow diagram expands portion of over-all flow diagram to show how amplitude scale factors are computed for left-hand term of second order.

the second order or lower, since it was written to demonstrate the feasibility of the analog program writing concept and to allow easy experimentation. Hence, the left side of the equations can be algebraic quantities or time derivatives of the first or second degree. The "terms" of the right side of each equation can take any of six standard forms that allow products and quotients of nonlinear factors. The general form of each "term" is

$$\pm \frac{C_\alpha}{C_\beta} \frac{V_1 V_2}{V_3}$$

in which C_α and C_β are constants, and V_1, V_2, and V_3 can be any dependent variables in the system of equations, including first and second derivatives. The six standard forms permitted by the digital program are

$$\frac{C_\alpha}{C_\beta} \qquad \frac{C_\alpha}{C_\beta} V_1 \qquad \frac{C_\alpha}{C_\beta} V_1 V_2$$

$$\frac{C_\alpha}{C_\beta} \frac{1}{V_3} \qquad \frac{C_\alpha}{C_\beta} \frac{V_1}{V_3} \qquad \frac{C_\alpha}{C_\beta} \frac{V_1 V_2}{V_3}$$

An analog computer "program" is not a set of sequential steps but is a simultaneous interconnection of computing components that obeys the same time-varying equations followed by the physical system to be studied or controlled. Figure 1 is a simplified flow diagram that shows the major steps followed by the digital computer program to arrive at the required analog program.

The input to the digital computer is the system of differential equations to be solved on the analog computer, with all coefficients, initial conditions, and expected limiting values on dependent variables. The digital computer stores this information in an input matrix and examines the left side of each equation in turn and assigns appropriate computing elements in the analog system. The computer then scales these left-side analog circuits to determine amplifier and integrator gains and potentiometer settings. This first scaling of the circuits for the left-side terms determines the scaling throughout the rest of the problem.

With the left-side computer program thus fixed, the digital program goes on to analyze each right-hand term, assigning potentiometers and potentiometer settings, summers, gains, multipliers, and dividers as needed. Each term is then joined back to the proper equation with the correct scale factor and gain for each integrator or summer. The output is typed out in a form that makes it easy to draw the analog schematic diagram.

Digital input form is straightforward

The digital computer program requires a statement of the differential equations to be solved, the initial conditions of variables, scale factors or maximum values expected, and static check values.

The digital program was designed to accept input statements written in commonly used engineering mathematics so that the engineer would not have to learn any special statement forms. The two exceptions are extremely simple: 1) d^2x/dt^2 and dx/dt are replaced by DDX and DX, respectively,

COMPUTER INPUTS

D N = K_1 * N - K_3 * N * M
D M = K_2 * M - K_4 * N * M

$K_1 = 0.511$
$K_2 = 0.622$
$K_3 = 0.644 \times 10^{-1}$
$K_4 = 0.98 \times 10^{-3}$

INITIAL CONDITIONS

$N_{ic} = 200$ units
$M_{ic} = 2.0$ units

MAXIMUM EXPECTED VALUES

$N_{max} = 3{,}300$ units
$M_{max} = 12.5$ units

STATIC CHECK VALUES

$N_{sc} = 200$ units
$M_{sc} = 10.0$ units

COMPUTER OUTPUT

FIG. 3. DIGITAL COMPUTER WRITES ANALOG PROGRAM FOR VOLTERRA'S EQUATIONS.

Two simultaneous nonlinear differential equations known as Volterra's equations were typed into the digital computer to illustrate the input form (above) and the output form (above right). The analog computer program or interconnection diagram is drawn directly from the typed output of the digital computer (lower right).

EQUATION 1

	INTEGRATOR I- 0	POT P- 0	INTEGRATOR I- 1	SUMMER S- 0
OUTPUT EQUATION			-0.0303N	
POTSET OR GAIN			0.	
MAXIMUM OUTPUT			-100.0000	
STATIC CHECK OUTPUT			-60.6061	
I.C. POT NO.			1	
I.C. POT SET			0.0606	

EQUATION 1-LOOP 1 GAIN = 1.

	SUMMER S- 3	DIVIDER D- 0	MULTIPLIER M- 0	SUMMER S- 0	POT P- 3
VARIABLE FROM	I- 1				S- 3
VARIABLE TO	P-3				I- 1
OUTPUT EQUATION	0.0303N				0.0155N
POTSET OR GAIN	1.0000				0.5110
MAXIMUM OUTPUT	100.0000				51.1000
STATIC CHECK OUTPUT	60.6061				30.9697

EQUATION 1-LOOP 2 GAIN = 1.

	SUMMER S- 0	DIVIDER D- 0	MULTIPLIER M- 1	SUMMER S- 0	POT P- 4
VARIABLE FROM			I- 1		M- 1
			I- 2		
VARIABLE TO			P- 4		I- 1
OUTPUT EQUATION			-0.0024N*M		-0.0019N*M
POTSET OR GAIN			0.		0.8050
MAXIMUM OUTPUT			-100.0000		-80.5000
STATIC CHECK OUTPUT			-48.4849		-39.0303

EQUATION 2

	INTEGRATOR I- 0	POT P- 0	INTEGRATOR I- 2	SUMMER S- 0
OUTPUT EQUATION			-8.0000M	
POTSET OR GAIN			0.	
MAXIMUM OUTPUT			-100.0000	
STATIC CHECK OUTPUT			-80.0000	
I.C. POT NO.			2	
I.C. POT SET			0.1600	

EQUATION 1-LOOP 1 GAIN = 1.

	SUMMER S- 4	DIVIDER D- 0	MULTIPLIER M- 0	SUMMER S- 0	POT P- 5
VARIABLE FROM	I- 2				S- 4
VARIABLE TO	P- 5				I- 2
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POTSET OR GAIN	1.0000				0.6220

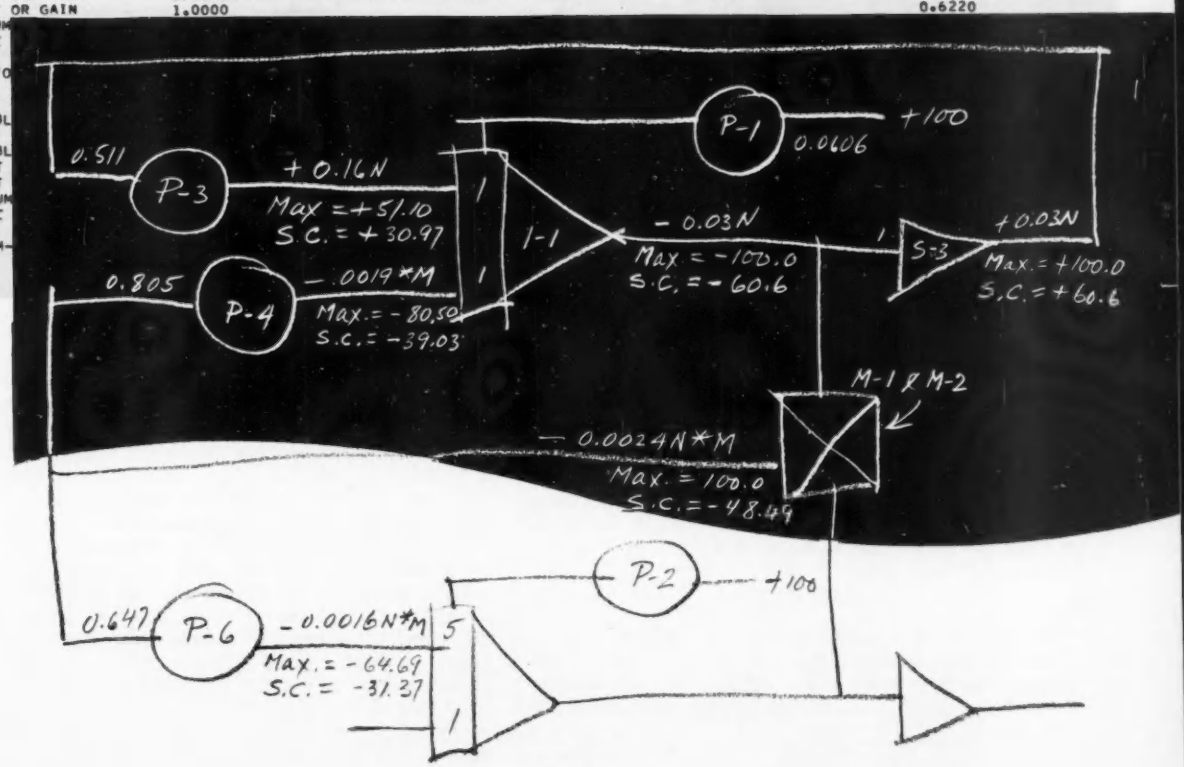
MAXIMUM
STATIC

EQUATIO

VARIABL

VARIABL
OUTPUT
POTSET
MAXIMUM
STATIC

NOTE M-



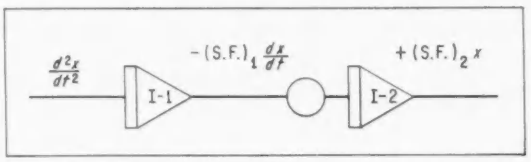


FIG. 4. Signal gains of analog computing components are adjusted to keep signal levels within linear ranges. These adjustments introduce amplitude scale factors that are calculated by digital program.

and 2) all numerical input is in floating point form. For example,

$$\frac{d^2x}{dt^2} = C_1 \frac{dx}{dt} + C_2 y$$

must be written

$$DDX = C_1 * DX + C_2 * Y$$

Constants, initial conditions, maximum values or scale factors, and static check values must all be listed in floating point form for the input.

The computer analyzes each character in the input equation and stores it in its proper matrix location. The only computations made during the input operation are those required to put the constants for each term in the form C_α/C_β, where C_α and C_β can be made up of as many as seven constants each;

$$C_\alpha = K_1K_2K_3K_4 \ldots K_7$$

and

$$C_\beta = K_1K_2K_3K_4 \ldots K_7$$

The left-side term of each equation is then examined in turn. A second order term is assigned two integrators, a first order term only one integrator, and an algebraic term gets a summer. For each integrator, an initial condition is assigned. Potentiometers are assigned to integrator and summer inputs where nonintegral gains are indicated by the term constants. All component assignments then go to an output matrix with their mathematical output expressions.

The amplitude scale factors for the computer solution may be specified by the engineer, but the digital program will compute them from the maximum values of first order and zero order terms, and algebraic sums. Figure 2 is a simplified flow chart of amplitude scaling for a second order left-side term.

Since differentiation is simulated on analog computers by working backward through successive integrations in order to minimize circuit noise, scale factors for the first order and zero order terms result as shown in Figure 4 when a second order term is simulated.

The digital program for calculating these scale factors can be understood from Figure 2. Using the maximum displacement value (X_{max}) the computer calculates a scale factor for the output of *I*-2.

$$(S.F.)_2 = \frac{100}{X_{max}}$$

All scale factors are rounded off so that the operator will have a scale factor that is easy to set manually. The first scale factor $(S.F.)_2$ is then substituted for $(S.F.)_1$ and tested against the maximum value expected for the first derivative.

$$(S.F.)_2 \left(\frac{dx}{dt}\right)_{max} \leqq 100$$

If this condition is true, $(S.F.)_1 = (S.F.)_2$ and the program assigns a "1 gain" to *I*-2. If the test condition is not true, a second test is made with the first scale factor divided by five:

$$\frac{(S.F.)_2}{5} \left(\frac{dx}{dt}\right)_{max} \leqq 100$$

If the second test condition holds, the computer assigns *I*-2 a "5 gain". If the second test condition is still not true, a third test assumes a "10 gain" on *I*-2, and if this still does not work the computer calculates a new scale factor:

$$(S.F.)_{I-1} = \frac{100}{\left(\frac{dx}{dt}\right)_{max}}$$

for which a "10 gain" is assigned to *I*-2 and $(S.F.)_1 = (S.F.)_2$.

Knowing the scale factors, the maximum outputs and static check values can be computed for each integrator.

The computer works out the analog program for the six types of right-side "terms" in a similar manner to that just described for the left-side terms. Each of the six types has a special program by which components are selected, connections determined, and scale factors calculated. All this information is then stored by the computer in the output matrix to be printed out for the analog computer operator.

How the program works

The example in Figure 3 was programmed for the Electronic Associates analog computer at Convair-Astronautics. Note that the format of the printed digital computer output, only a part of which is shown, translates easily to the analog schematic. Two multipliers, *M*-1 and *M*-2, were called out in the output where only one is needed. The call out on *M*-2 could have been eliminated with some additional logic that checked back to see if a multiplier was already assigned to perform the same multiplication.

The output format uses fixed-point number fields that have caused difficulty on some problems because the significant figures did not fall within the range of the fields. An extended program should use a variable field with fixed point numbers or a fixed field with floating point numbers. The detailed print-out is not necessary to this example, but is very useful when solving larger problems.

This digital program that writes analog programs has had limited use by Convair because it can work with only two types of nonlinearities—multiplication and division. The digital computer could be programmed to handle most nonlinearities commonly instrumented on the analog computer, but such programs would involve a great amount of logic and considerable programming time. Hopefully, automatic program compilers may make it economical to write these extended programs in the near future.

Bridge Autoblends Gas at the Pump

DEREK BARLOW,
Control Engineering

Besides looking different, British Petroleum Ltd.'s Autovista gasoline pumps use bridge circuitry to blend regular and super gas grades, and measures gas without loading the pumping system. Display readout on a stand ahead of where the auto pulls in allows the driver to check the grade, quantity, and cost of the gasoline delivered without leaving his car. A second stand housing the dispensing hoses is situated some feet back, close to the auto's filler cap.

Signal pickoff from positive displacement meters in the regular, super, and diesel fuel lines, Figure 1, is via two 6-in. diam plastic discs keyed to each meter shaft. As aperture holes in the disc successively illuminate two phototransistors, one disc provides quantity delivered signals, the other cost signals. In conventional gas pumps, a gear train on the meter shaft operates the quantity delivered dial, and a subsidiary gear train operates the cost dial. This mechanical computer imposes an additional 3 psi load onto the pump's normal 15 psi bypass pressure. The Autovista approach allows use of less costly turbine pump and eliminates a stage in the air elimination filter.

To adjust the volume and cost signals to different measurement units—BP plans to market the installation throughout Europe—the number of holes in each disc is varied so that each pulse represents 1/500 gal or 1/100 liter. This is more than accurate enough to satisfy local statutory requirements. In practice, the quantity-delivered disc is sealed on the meter shaft by the Weights and Measures authorities. Price discs are prepared in the local currency, and in the event of price changes a new disc is installed to give the correct output.

For the customer's readout, both the quantity delivered and price pulse trains feed impulse counters that operate four decade dial drums carrying 40-mm high numbers. The independent display of quantity and price provides a visual check against malfunctioning of the transistorized counters. A quantity/cost switch at the dialing station connects a reversible counter to the appropriate pulse train. Two 10-position switches set the amount to be dispensed into the counter as a number of either quantity or cost unit pulses to be reached before cutoff.

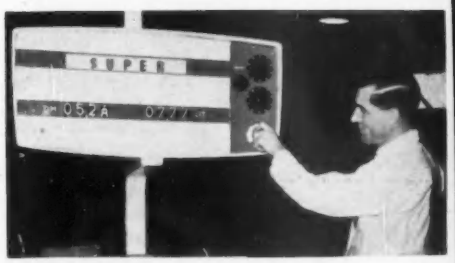
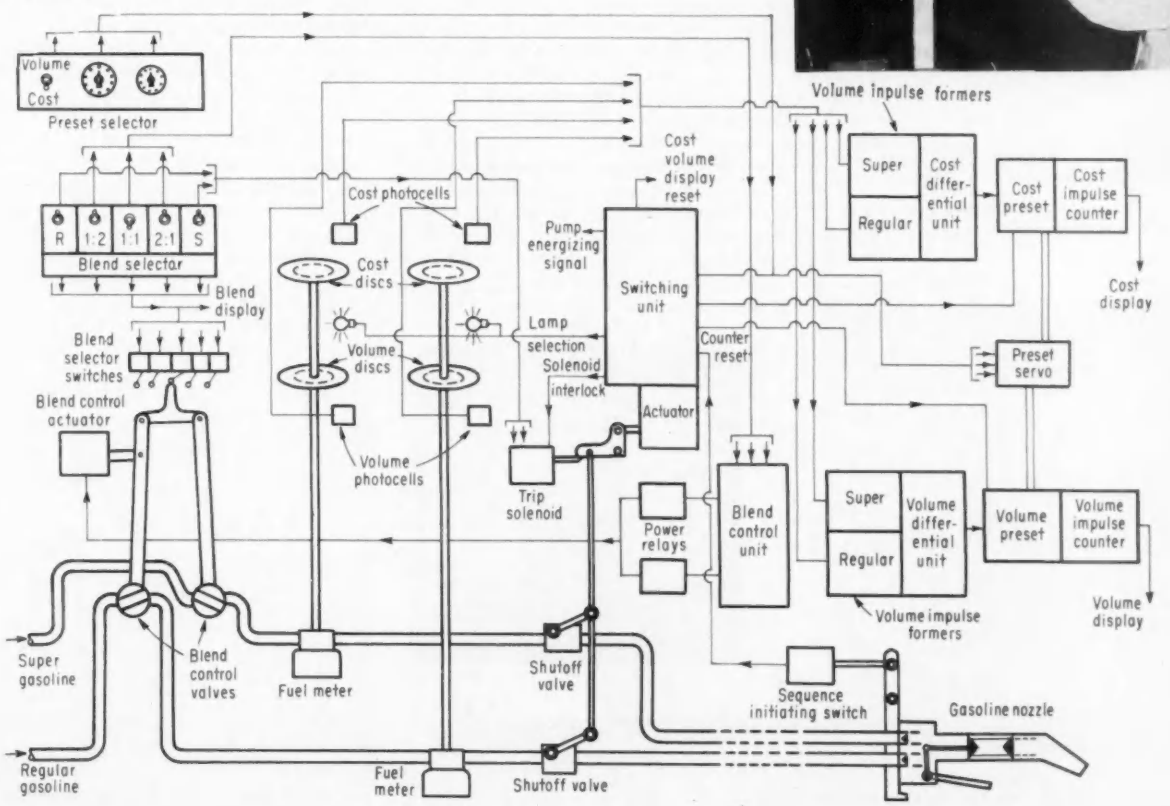
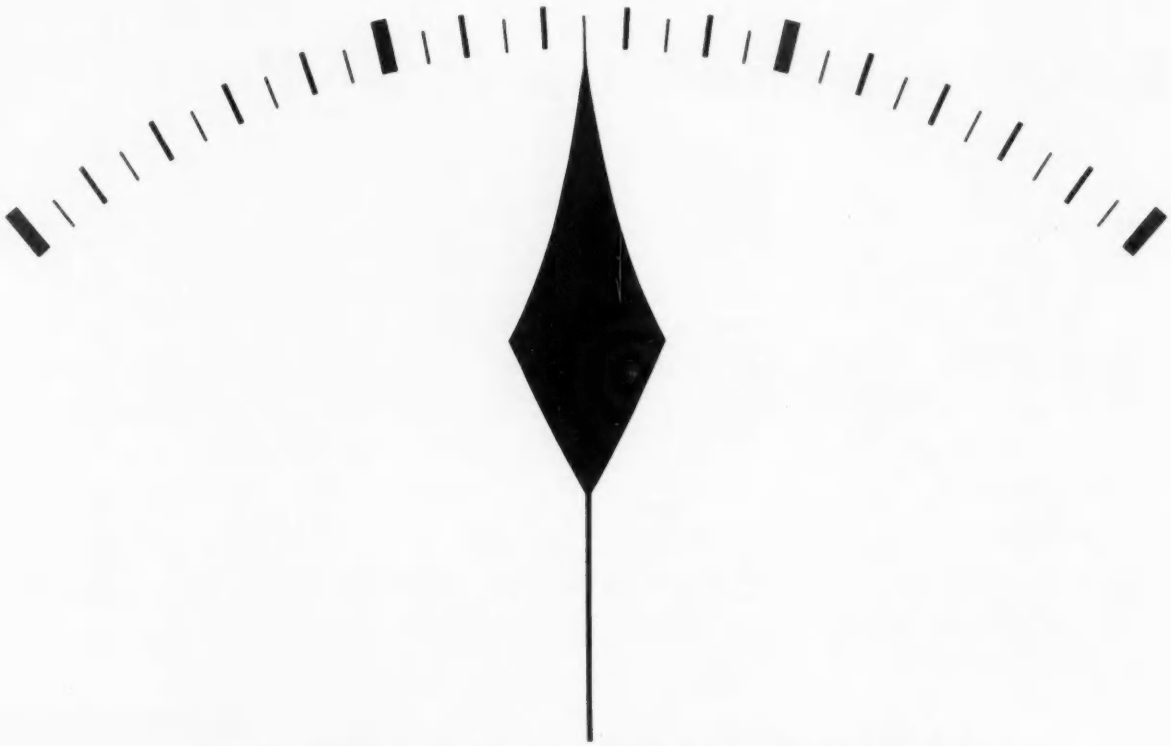


FIG. 2. Grade and quantity are dialed in.

FIG. 1. Pulses measure quantity and cost, control blending. Diesel fuel line and metering circuits are not shown.





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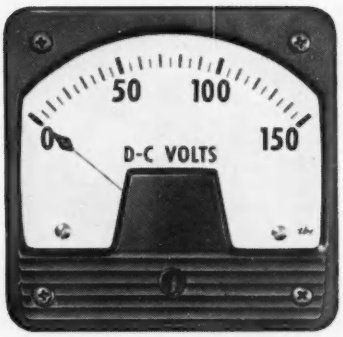
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When incoming pulses reduce this preset value to within 15 counts of zero, a servo link partially closes the main flow valve in each of the supply lines. To allow for valve inertia, the valves close one pulse before zero.

Autovista provides automatic blending of three intermediate grades between the regular and super grades stored at the filling station. This eliminates the need for intermediate grade storage tanks and extra pumps. A six-position switch on the dialing unit selects one of the six possible grades—five gasoline and one diesel. Selection of any grade other than the basic regular, super, or diesel initially sets both blend control valves in mid-position. Fine trimming is done electronically.

The system volume blends by feeding quantity delivered pulses from the positive displacement meters in both the regular and super fuel lines into a capacitance bridge. The blend switch sets the arm capacitance ratio of the bridge to 1:2, 1:1, or 2:1. Incoming pulses are integrated and form dc signals proportional to the volume delivered in each line. When the volume ratio is correct—proportional to the capacitance values selected—bridge output is zero. Incorrect blending produces a dc error signal that operates one of a pair of primary relays. A rotary actuator driven through the relays provides continuous fine positioning of the blend valves.

In operation, the filling station attendant dials in the grade required, selects whether control is by cost or quantity, and dials in the amount. Figure 2. Lifting the hose from its stand initiates the sequencing action after a 3-sec delay. During this delay period the price and quantity display dials return to zero from their readings of the last sale, and the new demand value is inserted as the setpoint for the reversible counter. Next the grade display panel rotates to the correct position and automatically energizes the correct blend control and shut-off valves. Solenoid operated mechanical interlocks insure that shut-off valves on unwanted grades cannot be opened while the grade display panel is in that position. Finally, the pump motor starts up to provide delivery pressure, the operator controlling the filling rate with a nozzle grip valve.

Copulometer, Drinkometer Report Rodent Behavior

DON WINSTON
McGraw-Hill News

Scientists at Stanford Research Institute—proceeding on a grant from the Psychopharmacology Service Center of the U. S. Public Health Service to study long term drug effects on animals—are developing a truly statistical approach to automatic biological and physiological testing.

The SRI team, under Dr. Leon S. Otis, is aiming at a "living environment cage" in which stimuli can be programmed and introduced automatically, and behavior can be recorded without human observers. One special purpose transducer under development is a copulometer, Figure 1, originally designed at Johns Hopkins University under a separate National Research Council grant and now being refined at SRI. As the name implies, the copulometer measures sexual behavior. So far it has only been used with rats, though it is expected that primates could be tested in this manner.

Here's how the copulometer works: One end of a vertical rod is fastened to the cage floor, and the other end extends up through the roof of the cage to a displacement sensor. This sensor is actually a converted permanent magnet loudspeaker with the rod connected to the voice coil. Cage floor vibrations move the voice coil and modulate a small current.

When the sensor output is strong enough to indicate activity in the cage a gating device turns on a strip chart recorder and a movie camera. At present, the amplitude threshold must be set empirically for each pair of animals; the operator determines by observation the signal strength that indicates copulation. When there is no action in the cage the recorder merely marks time at 1 min intervals. Mirrors allow the camera to photograph a split image. Half the picture is a view looking through the bottom of the cage at the rats; the other half shows the strip chart.

Thus far SRI scientists have been able to distinguish copulation patterns from fighting patterns with about 85 percent accuracy by reading the chart alone. Ejaculation can be distinguished from copulation about 95 percent of the time. Besides freeing human observers, the copulometer eliminates the need to induce heat artificially in the female before introducing her to the male. With observation time no longer critical from a cost viewpoint, experimenters put male and female together and wait.

A drinkometer, Figure 2, provides detailed records of the drinking activities of small animals. Measured amounts of water are pumped into a stainless steel nipple mounted on the cage wall. On either side of the nipple are insulated metal plates connected to an 8,000-cps signal source. The animal acts as an antenna and picks up a minute charge that is transferred to the nipple, recording each drink on a print-out device.



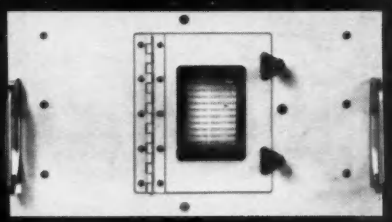
FIG. 1. Sensor atop cage activiates recorder and movie camera on floor.

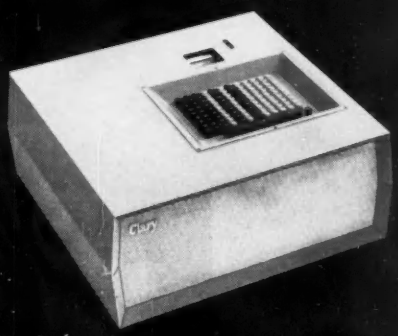


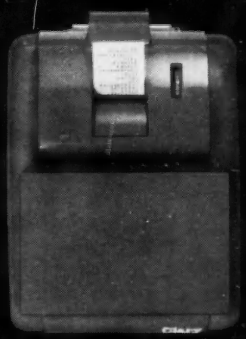
FIG. 2. Pump (right) feeds measured amounts of water to nipple for wall of cage.

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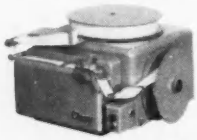
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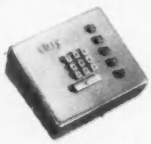
TIME-DATA PRINTER. Accepts remote source information, records it with exact time to nearest second.



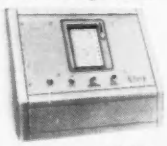
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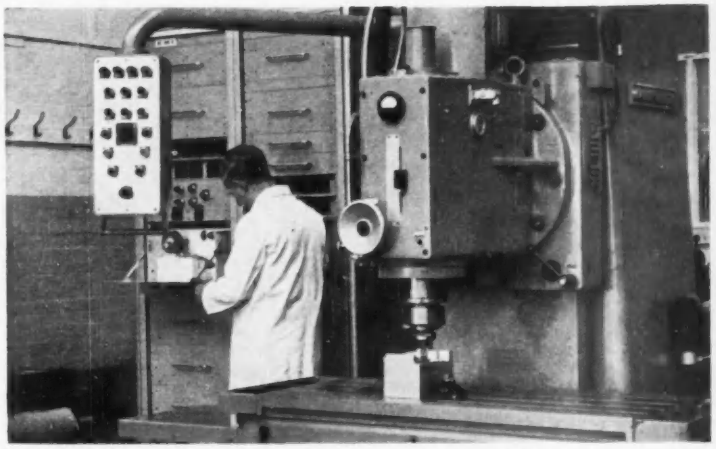
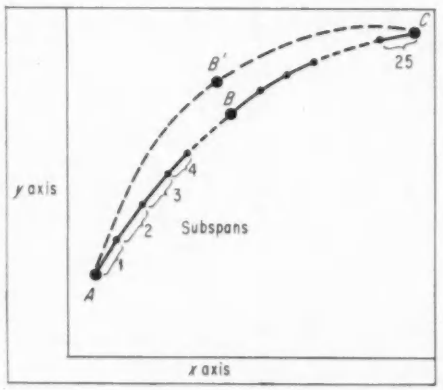


FIG. 1. Droop and Rein FS 80 N miller has EMICON error forecasting control system.

FIG. 2. Parabolic contour is divided into subspans.



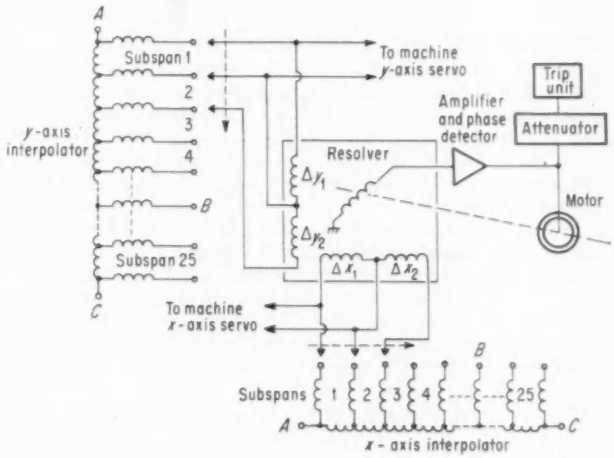


FIG. 3. Resolver follows feed angle over two subspans.

S. C. ANSELL
E.M.I. Electronics Ltd., England

Tape controlled machine tools are often equipped with a safety device that stops the machine as soon as an error has been made. But the workpiece must be scrapped, and if it has a complicated contour and the irregularity occurs near the end of the program, considerable time is wasted.

The vertical miller shown in Figure 1 has an EMICON continuous contouring system fitted with a resolver circuit that provides advance warning of errors due to faulty coding on the tape. The maximum angular change allowable between interpolation points is preset, and any signal calling for a sharper curve sounds a warning and stops the miller before the error affects the workpiece. As soon as the irregularity has been investigated and corrected, cutting can continue.

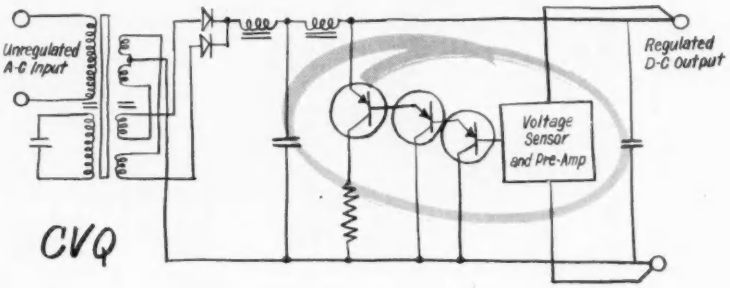
Figure 2 shows how a contour is specified by three points A, B, and C and divided into 25 subspans. The x and y voltages corresponding to the endpoint of each subspan appear at parabolically distributed taps on the two interpolation transformers in Figure 3. Actual x and y control signals are obtained by switching sequentially along the taps, causing the cutter to move through subspans 1 through 25.

To sense potential errors, a 2-axis resolver measures the feed angle over two successive subspans—the one being cut and the following one. Outputs corresponding to these x and y subspan pairs feed two sets of series connected stator windings on the resolver. A motor connected to the resolver rotor through an amplifier and phase sensitive detector nulls the rotor so that its angular position is the same as the cutter feed angle over the two subspans. As the cutter reaches the end of subspan 1, stepping switches advance, feeding subspan 2 information to the miller servos and simultaneously connecting subspans 2 and 3 to the resolver.

As long as the cutter follows a smooth curve, the change in feed angle (and resolver rotor position) is negligible; on an arc with a 2-in. radius, for example, the change in feed angle between subspans is only 0.57 deg. But if position irregularities are present (if the miller is suddenly told to follow the arc AB'C, for instance), then the feed angle changes appreciably. When the resolver is switched to this conjunction, an error signal arising from the motor's long time constant appears at the amplifier output. This signal trips the miller drive and stops the cutter before it is instructed to follow a wrong path.

To accommodate programmed curves, a variable attenuator ahead of the trip unit is adjusted so that the miller is turned off only when the error signal represents a curve sharper than is allowed in the program. Allowable angular variations are switchable between 8 and 60 deg. A special signal inserted on the tape by the programmer inhibits trip unit operation when the miller is specifically instructed to machine a corner.

SOLA writes this new Rx for reliable d-c power



This schematic tells "CVQ's" secret at a glance . . . how SOLA's remarkably reliable new power supply achieves d-c output ideal for computers and other voltage-sensitive equipment. "CVQ" integrates the advantages of shunt-circuit regulation with the *inherent* high stability of the SOLA static-magnetic transformer. And the result is transistorized voltage regulation *with split-cycle response!*

"CVQ" answers the demands of dynamic loading. Voltage variations are ironed out down to the last transient — even to the last ripple of the a-c source. And the SOLA static-magnetic transformer *automatically* prevents damage in event of a short circuit.

SOLA "CVQ" d-c power supplies are available *right now,* in a wide range of ratings; also in custom units built to your specific requirements. Advantages include:

- More watts per dollar.
- Continuous automatic protection without fuses, both for output short circuits, and for open circuits in the voltage-sensing circuitry.
- Output regulated within ±0.04% for line voltage variations ±15%; 0.2% static-load regulation, 0 to full load. Excellent response time.
- Standard models available in the 120-watt range for 5, 6, 10 and 12 volts d-c (100-130/181-235/200-260 volt input).
- Compact mechanical layout — only 12¼ x 5¼ x 19".

Get full facts by writing for new SOLA Catalog DCX-361A. Or telephone HEmpstead 9-2800, Elk Grove Village, Illinois.



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Transistors Switch High Voltage in Electric-Writing Recorder

J. W. STREATER
Brush Instruments

Transistor switches are fast and reliable, but they can handle only low voltages. The problem: designing one that would switch 300-500 volts in a new electric-writing event recorder used for recording two-state data on moving electrosensitive chart paper. The basic stylus circuit of the recorder is shown in Figure 1A. With switch S in position 1 the full output of the supply appears on the stylus and breaks down the dielectric coating on the paper. Once this happens the resistance of the paper is low, and a trace is drawn. R determines the writing current, typically 4-10 ma. When the switch is in position 2, current through R_{SW} reduces the stylus voltage, and writing stops.

To take full advantage of the electric writing scheme the switch must be faster than an electromechanical relay. However, it need not provide perfect open and short circuits. A transistor could be connected as a voltage sensitive switch, as shown in Figure 1B, except that transistors capable of operating with collector voltage of several hundred volts are not available.

But if a step-down transformer is connected between the stylus circuit and the transistor and if a source of high voltage dc pulses is substituted for the continuous dc supply, Figure 2, then a standard transistor, Q_2, can be used. Now the peak collector-emitter voltage is equal to the peak supply voltage divided by the transformer turns ratio. When the base current is near zero (voltage V_1 small) the collector-emitter connection shows a high impedance, and the transformer looks like an inductance shunted between the stylus and ground. If the pulses are short, little current will be diverted through this inductance, and the stylus will write. As V_1 is increased Q_2 "turns on" and appears as a near short circuit across the transformer. This low impedance (multiplied by the square of the turns ratio) is reflected to the stylus circuit, stopping the trace.

Since the switch package was to be no larger than a relay, the major design problem was specifying a small transformer that would have high primary inductance (requiring a large number of turns) and low winding resistance (requiring few turns of large wire). The turns ratio was established as 12:1 step down so that a transistor could handle the peak voltage. To prevent the stylus from writing, the effective resistance looking from the stylus into the transformer, $(R_{transistor} + R_{secondary})\ n^2 + R_{primary}$, has to be less than about 4,000 ohms. A convenient power supply circuit provides pulses of about 100 microsec duration; with this pulse length the transformer primary inductance must be at least 5 or 6 henries for the stylus to write evenly. After testing several prototypes, a design having the following parameters was selected as the best compromise: primary inductance = 7 henries, primary resistance = 1,100 ohms, and secondary resistance = 17 ohms.

Transistor Q_1 must have a V_{CE} of 35 volts or more and a saturated current gain of at least 20 for a collector current of 200 ma. The choice of an NPN or PNP transistor depends on the polarity of switching voltage V_1. Fast switching speed is not required because practical chart paper speeds limit the resolution. The inexpensive 2N35 was found to be the most suitable NPN type.

In the circuit of Figure 2, Q_1 acts as a phase inverter and provides additional gain. With no signal at the input terminals, V_1 is about 4.5 volts, Q_2 conducts, and the stylus does not write. When a positive signal is applied to the base of Q_1, the Q_2 base current is reduced to nearly zero, Q_2 no longer conducts, and the stylus begins to write. With average transistors the values shown provide a current sensitivity of about ¼ ma corresponding to a voltage sensitivity of 9 volts. For lower voltages the 27-kilohm series resistance can be reduced; higher voltages cause no damage if the dissipation of this resistor is not exceeded.

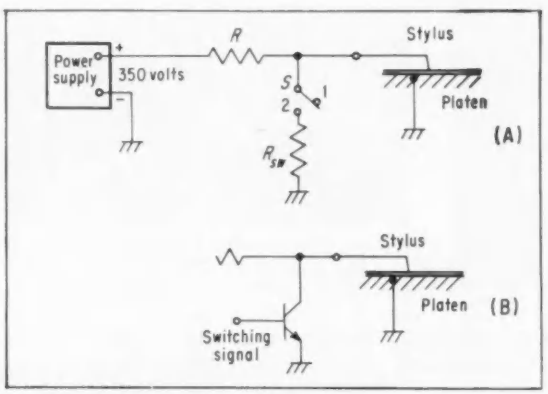
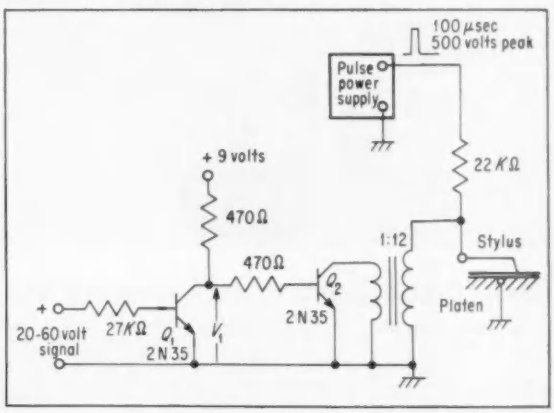


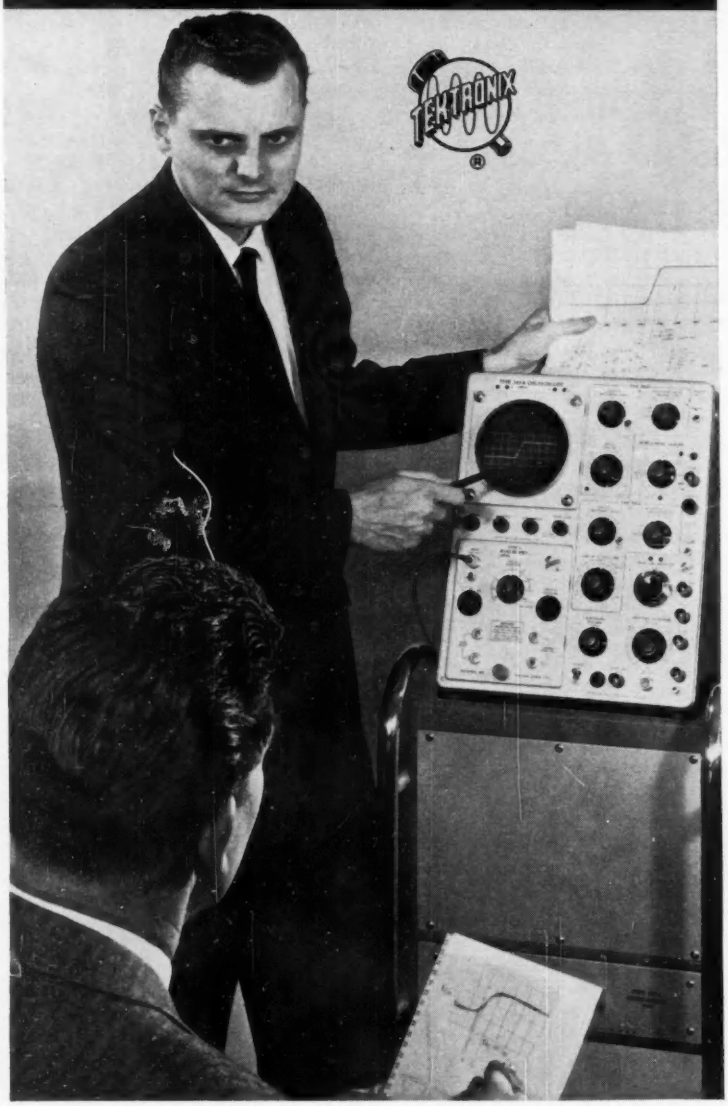
FIG. 1. Basic circuit for electric writing (A) and how a transistor could be used for switching if high voltage transistors were to be had (B).

FIG. 2. Transformer coupling enables transistor to switch high voltage pulses.



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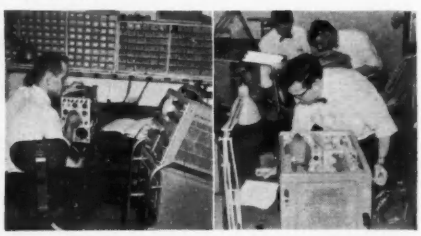
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A 350 peak watts pulse power supply suitable for recorders with up to 35 channels is diagrammed in Figure 3. Each stylus requires 20-ma current pulses with a peak voltage of 500, or 10 watts peak per stylus. Pulses are produced by a unijunction transistor and amplified by two successive power transistor stages. The power transistors function as switches; they do not conduct between pulses, are driven into saturation during pulses.

Each current pulse makes a single dot on the paper, and for even traces the pulse rate should be varied with changes in chart speed to hold the spacing between overlapping dots nearly constant. By changing R_1, pulse rates ranging from 0.1 to 1,000 pps are obtained. The maximum pulse rate is limited by heat developed in the power transistors. This limits the present maximum chart speed of the instrument to 125 mm/sec. At this speed the chart resolution of ¼ mm represents 2 millisec.

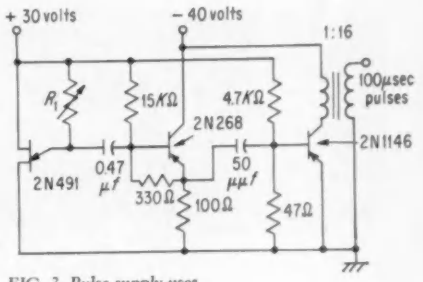


FIG. 3. Pulse supply uses unijunction and power transistors.

Pneumatic Filters Smooth Computer Data

J. C. RHODES
American Oil Co.

In applying digital computers to the control of modern refinery units, many input signals are found to be pneumatic. Typically, such signals have instrument and process noise with an amplitude of 2 to 7 percent of full scale. Some technique must be found for smoothing these noisy signals if the computer is to accurately estimate what the plant is doing.

Most schemes for using digital computers in process control are based on mathematical models that assume steady state operation of the plant. In this type of operation, the instruments are usually scanned at selected intervals. By scanning at a frequency at least twice that of the noise and averaging several scans, an accurate estimate of the process signal can be made. But this technique requires an expensive computer with a large memory and ability to scan rapidly.

A simple, inexpensive way to reduce noise level on pneumatic signals is to install a filter or snubber, Figure 1, ahead of the transducer used to convert the pneumatic signal into an electrical signal acceptable to the computer. The filter consists of a 6-cu. in. tank, a short length of glass thermometer tubing, a grommet, and fittings for mounting the tubing securely in one end of the tank. The pneumatic signal passes through the glass tubing into the tank, which is attached directly to the transducer. The time constant of the filter is a function of the flow resistance of the tubing, and the volume of the entire pneumatic line downstream from the tubing, including the transducer. By selecting tubing of the right bore (usually 0.003 to 0.005 in.) and cutting it to length, constants up to 30 min can be had.

To measure the time constant, a gage is inserted between the tank and the transducer. The gage is filled with liquid and mounted upside down to minimize its added volume. There should be no leaks. When a fixed pressure is applied upstream from the tubing, the initial rate of change of pressure in the tank is a measure of the system time constant.

The proper time constant for a particular signal is a compromise between the noise attenuation desired and the permissible lag. Typically, the noise has a period of 2 min or less and can be reduced in amplitude to less than 1 percent of full scale without introducing serious lags—especially where steady state control models are used. The time constant required for a certain attenuation and the resultant phase lag can be obtained from conventional handbook plots that indicate the magnitude and phase versus frequency ratio for first-order lags.

A filter of this type has been used on the signal from a radiation densitometer. Because of radiation hazard, the source had been chosen so weak that the noise-to-signal ratio due to statistical scattering was about 15 percent of full scale and the average period was about 1 min. Satisfactory electrical filters for this system would be expensive. Instead, the electrical signal was transduced into pneumatic form, filtered by the "bomb," and transduced back into electrical form, Figure 2. The noise was reduced to less than 1 percent of full scale.

In addition to being economical, the filter described is practically drift free and tamper proof. Such devices are proving useful in computer control of the world's largest pipe still, American Oil Co.'s 140,000-bpd crude unit at Whiting, Indiana (CtE, June 1960, p. 40).

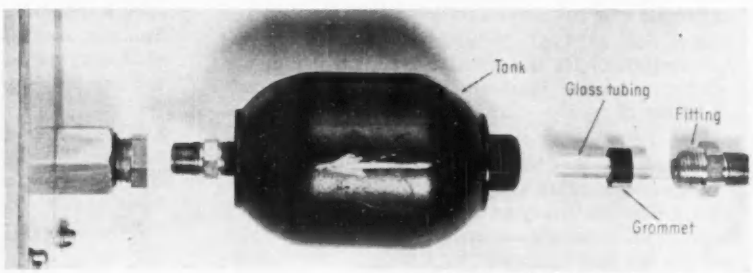
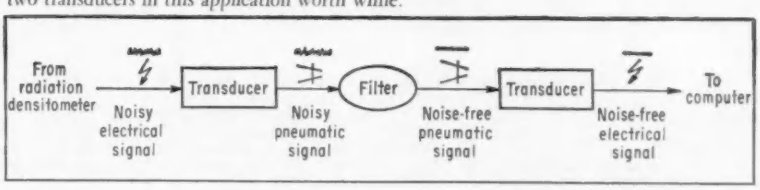


Fig. 1. Noise filter is simple and rugged.

Fig. 2. Performance and low cost of filter made using two transducers in this application worth while.



Here lie 707 rolls of paper tape shot full of holes by Tally Perforator #171

...Long may she run!



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As of Feb. 13, 1961, perforator #171 had completed 70,700,000 cycles of accurate operation with only two minor mechanical break-downs. Repairs were made in a matter of minutes. This is a record of reliability that speaks for itself.

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10

NEW PRODUCTS

MULTICHANNEL A/D CONVERTER links computer to the process.

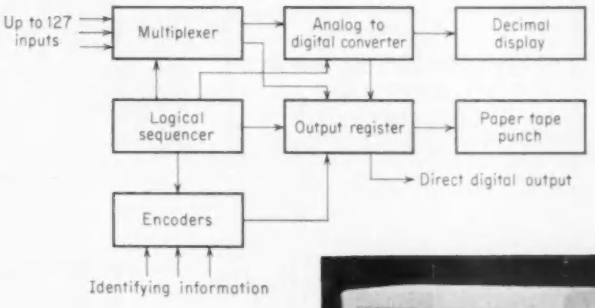
MADE (Multichannel Analog to digital Data Encoder) uses solid state digital techniques to convert up to 127 analog voltage inputs (±10 vdc nominal) into digital signals suitable for entry into a digital computer. System is designed either for on-line or off-line operation, with data storage on punched paper tape for the latter.

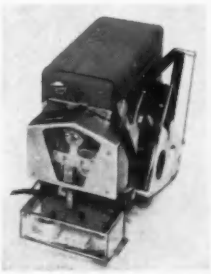
As shown in simplified block diagram below, the multiplexer sequentially connects the inputs to the converter. Any digital inputs are connected directly to the output register. The converter provides binary or any bcd output to the register; it also feeds a decimal readout. The output register accumulates and organizes the data into format suitable for tape punch or a computer.

The encoders digitize any identifying information necessary to describe the readout data, such as start and stop positions and meter ranges. The logic sequencer controls the other components of the MADE unit: it advances the multiplexer, triggers the conversion, controls data flow to the output register, determines the tape format, and generates special codes such as carriage return.

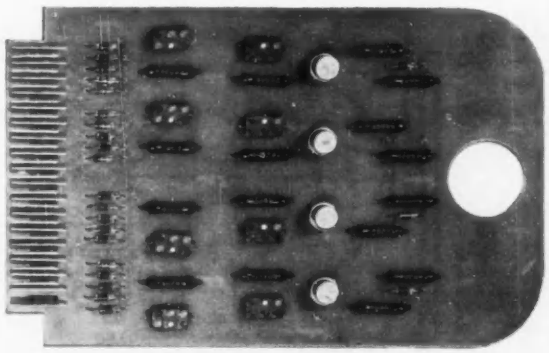
Conversion accuracy is to within ±0.1 percent of full scale for analog inputs, giving three decimal digits plus an overflow digit. On-line sampling rate is 1,000 readings per sec or 10,000 per sec for digital inputs only. Off-line rate is limited by punch speed—up to 55 readings per sec. When sampling rate and number of inputs allow sufficient time for contact closures, relays can be substituted for static switching, and accuracy can be maintained with inputs as low as 1 volt.—Mechanical Div., General Mills, Inc., Minneapolis, Minn.

Circle No. 309 on reply card









A DC-200 two-circuit flip-flop card, forerunner of two new series of industrial logic circuits: one with more circuits per card, another with lowered environmental requirements also.

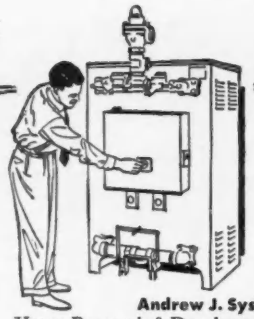
TRANSISTOR DIGITAL CIRCUITS designed for industrial machine control.

Digital transistorized circuits, originally designed for military applications, have been redesigned for industrial machine control. This manufacturer's CD series of plug-in logic cards (4½ x 7 in.) is now available with Hi Density packaging to reduct cost per circuit. A second line of cards will be available with fewer components and an easing of environmental and circuit tolerance requirements.

Hi Density four circuit per card flip-flops sell for $60.80 compared with $40.95 for the manufacturer's standard two-circuit card. Approximate prices of four circuit per card flip-flops and eight circuit per card gates with lowered environmental requirements are $55-59.

From another department (Industrial), the manufacturer is also making available NOR static control circuits, one circuit per 2½ x 4 in. card, which have been proved for machine control in manufacturing operations within the division's parent corporation.—Military Group, Delco Radio Div., General Motors Corp., Kokomo, Ind.

Circle No. 310 on reply card



Andrew J. Syska,
Hayes Research & Development Engineer Reports . . .

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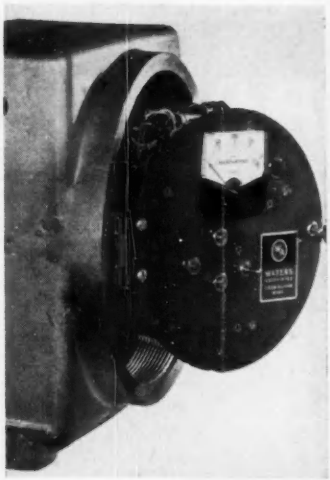
For a comprehensive picture of the Molecu-Dryer, write for Bulletin 5703.

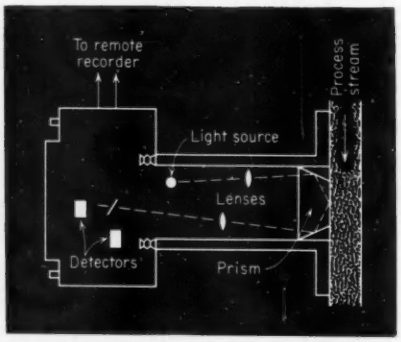
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Refractometer (left) with panel ajar, showing built-in meter. Sketch above diagrams operation.

IN-LINE REFRACTOMETER measures stream under actual process conditions.

Process streams that are dark, extremely viscous, or contain large amounts of solids cannot be measured by a differential refractometer where the sample must be transported through small sample lines and cells. This in-line refractometer overcomes the transportation and light transmission problems of these streams by using the critical angle technique of measurement in the process line.

Mounted in an explosion-proof housing, the unit can be attached to the wall of a pipeline or tank. Principle of operation is shown in the schematic above. Light from an incandescent lamp is beamed through a lens and out the back of the housing to a prism in contact with the sample. The beam is refracted at the prism-fluid interface and directed back through a deflector to two CdS detectors. One of these is located in the pure white light section; the other, at the critical point where the beam changes from light to dark. Changes in refractive index cause changes in light falling on the one photocell. The other cell remains in full intensity portion of beam. Light changes on the cell are signaled to an amplifier which causes a servomotor to drive a glass deflector plate in the beam. Plate's movement returns the beam to optical null, and this movement is a measure of process stream concentration. A pot geared to the null balancing motor gives a signal to the refractometer's meter and to a remote recorder.

Ranges available are 0-0.005 to 0-0.2 RI; sensitivity is to ¼ percent of full scale; accuracy is to ±½ percent FS; and speed of response is 90 percent in 20 sec. Price: $2,500.—Waters Associates, Framingham, Mass.

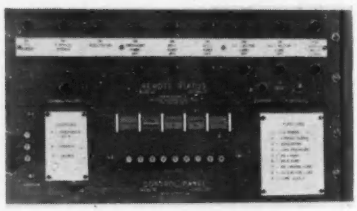
Circle No. 311 on reply card

SYSTEMS

BANKING EDP

Newly announced for bank data processing, the B270 system provides automatic proof and transit operations and also converts "on-us" items to magnetic tapes for computer processing. In addition, it can be used for automatic deposit analysis as well as account reconciliation. Included in the system are a central processor, card reader, sorter-reader, multiple tape reader, and magnetic tape unit. Sorter-reader is said to be the world's fastest, using magnetic ink character recognition to read checks and deposit tickets at 1,560 items per min. System prices will range from $252,130 to $366,130; monthly rentals will be $6,165-8,860. —Equipment & Systems Div., Burroughs Corp., Detroit, Mich.

Circle No. 312 on reply card



FAIL-SAFE SUPERVISOR

Maximum reliability is built into the MARC IX solid state supervisory

To go where the stars roam, Man is collecting, correlating, and assimilating more data than at any time in history



● **EPSCO-WEST high speed digital data system now in operation at Lockheed's satellite systems development laboratory.**

New *Epsco-West* High Speed Digital Data Acquisition and Processing System Speeds Space Probes at Lockheed

To conquer space, man is gathering and interpreting more data from more sources over a shorter time space than ever before. A new Epsco-West data system aids this quest at Lockheed/Sunnyvale's Missile and Space Division.

The Need for Centralized Data Gathering

Not long ago, the instrumentation engineer could accumulate data and analyze its effect on satellites, missiles and other space vehicles with the aid of relatively simple instruments—strip chart recorders, oscillographs and associated low speed data-logging devices.

Now, with the large syndrome of environmental events, space research demands high speed, centralized, flexible data-gathering facilities. Some of the environmental situations that must be instrumented at Lockheed include loads of 500,000 force-pounds down to 5, with instrumented load gradations as small as 0.02 force-pound—all recorded to 0.5% accuracy. Meanwhile the satellite can be experiencing a heat rise of 200° F. per second and a 1000 g shock in 10 microseconds.

To record the structural, dynamic and electrical/electronic performance of the specimen under these stringent conditions, Epsco-West designed and produced a flexible, accurate, and fast data system.

System Capabilities

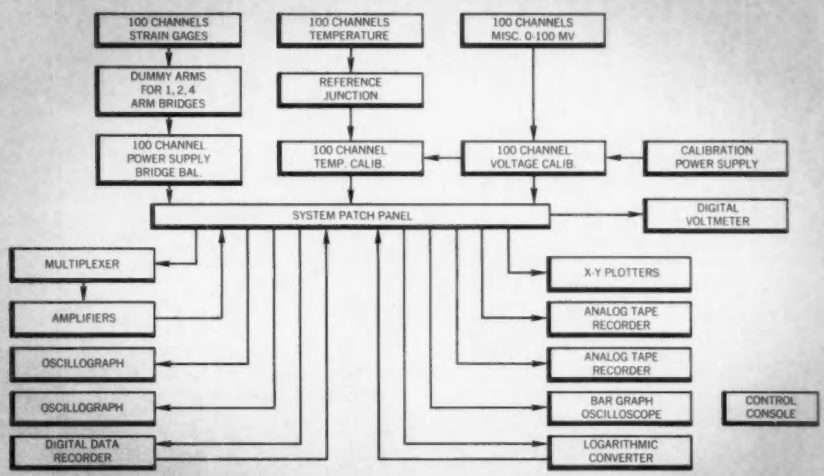
Briefly, the new Epsco-West system can handle 200 channels of information from any of three sources: strain gauge bridge signals, thermocouples, and miscellaneous millivolt signals. Any combination of these three types of signals can be patched up to a maximum of 100 channels for any one type of signal.

The system records data digitally at 5000 or 10,000 samples per second on magnetic tape. Editing facilities are provided to transcribe initial recordings onto a second magnetic tape with a format acceptable to either IBM 704 or 709 computers. All, or any section of the initially recorded magnetic tape may be transcribed into computer format or connected by DAC's to analog outputs and presented on the system's X-Y plotters.

The system also provides for simultaneous and parallel analog recording on two 14 track magnetic tape recorders and two 50 channel recording oscillographs. In addition, a bar-graph-type presentation on an oscilloscope is offered for "quick-look" purposes on any of 40 selected channels.

TECHNICAL FEATURES

- Low level multiplexing allows 40 wide band differential amplifiers to operate 200 channels. Multiplexing techniques saved approximately one fourth over the cost of comparable systems.
- Automatic accuracy check and fault finder ensures overall system accuracy and simplifies system maintenance. Accuracy of the system is better than ±0.1% of full scale excluding the end instrumentation and amplifiers.
- Completely flexible, the system can record from 1 channel at 10,000 samples per channel per second rate to 200 channels at a 50 sample per channel per second rate.



More Information Available

Epsco-West engineer William F. Kamsler has prepared a technical paper, given at the 1960 ISA conference, which completely describes this system. For a free copy, please write us or call your nearest Epsco-West engineering representative whose name is listed below.

Epsco-West *First in Data Control*

A Division of EPSCO Inc., Cambridge, Mass.

240 E. Palais Road • Anaheim, California

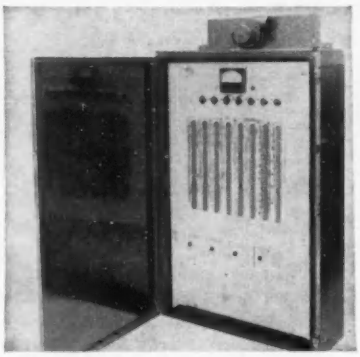
Phone: PRospect 2-1000

EPSCO-WEST ENGINEERING REPRESENTATIVES:

CALIFORNIA, Beverly Hills, Moxon Electronics Corporation • **CALIFORNIA, San Diego,** Moxon Electronics Corporation • **CALIFORNIA, San Mateo,** Moxon Electronics Corporation • **COLORADO, Denver,** Hytronic Measurements, Inc. • **NEW MEXICO, Albuquerque,** Hytronic Measurements, Inc. • **TEXAS, Fort Worth,** D. B. Carey Company • **UTAH, Salt Lake City,** Hytronic Measurements, Inc. **WASHINGTON, Seattle,** Comptronics.

control system. Intended for applications requiring fail-safe operations, the MARC IX is of the select before command control type. Sequence of operation is: 1) station and function selection, 2) code lock of remote operation function to prevent false control, and 3) command. Price: $200-400 per function. Moore Associates, Inc., San Carlos, Calif.

Circle No. 313 on reply card



REAL-TIME COMPUTER

The CM-3 analog computer-controller is designed to provide real-time control for fractionating towers, butadiene processing, and other multivariable processes. Computation techniques may be either feedforward or feedback. From five to 10 inputs and one to three outputs can be accommodated. Modular construction permits custom units for each application. The unit can also be used for operator guidance or equation solution for engineering design and analysis. Prices vary from about $5,000 to $10,000.—Dresser Electronics, SIE Div., Houston, Tex.

Circle No. 314 on reply card

DATA HANDLING & DISPLAY

COMPUTER INTERROGATOR

The 2502 interrogator, resembling an electric typewriter with viewing screen, can be used by office personnel to send and receive detailed information to and from a remotely located computer. A 40-key alphanumeric keyboard, using a six or seven-bit binary code, transmits questions at 15,800

SELECTIVE TONE SIGNALING

OSCILLATOR STABILIZER

RESONANT RELAY

TRANSMIT ENCODE

ON 1 2 3 ···· n

OFF

FREQ.

THOUSANDS OF FUNCTIONS PER CHANNEL

RECEIVE DECODE

FREQUENCIES 60-1000 CPS

FOR RELIABLE

- Selective Calling
- Remote Control
- Process Control
- Traffic Control
- Telemetering by wire or radio.

Please write for Catalog 563.

STEVENS INCORPORATED ARNOLD

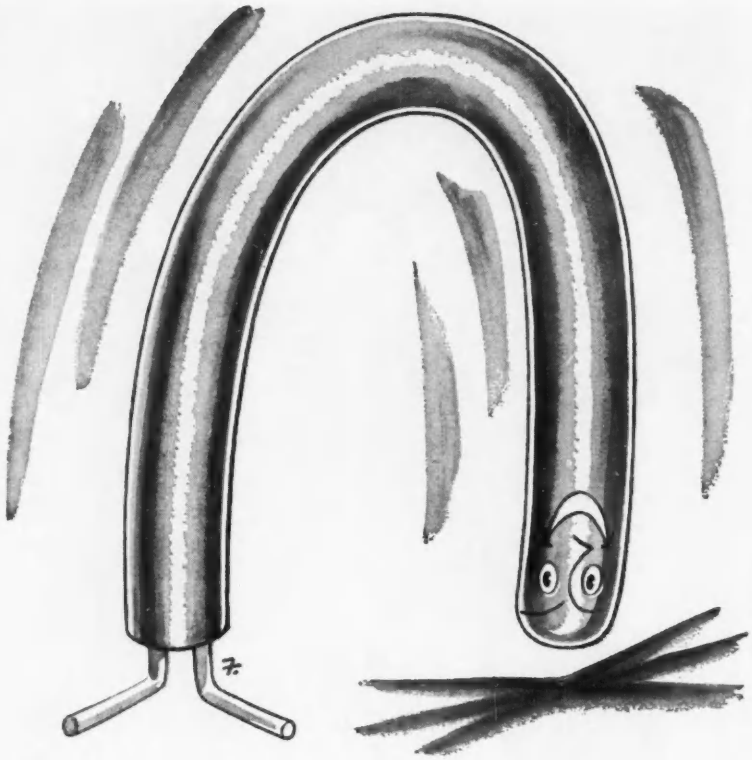
QUALITY SINCE 1943

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←CIRCLE 152 ON READER SERVICE CARD

CIRCLE 153 ON READER SERVICE CARD



Ceramo®* Thermocouples will bend over backwards to fit your job!

All of us "Ceramo*-Couples" can bend to almost any configuration, and we don't break our skins, or lose insulation either! When they put us together, they did the job "right."

Over ten years ago, Thermo Electric invented us. Since then, we've multiplied to so many types and sizes that we can do almost any job — and do it better too! We measure temperatures from minus 450°F to 4000°F and higher. Pressures up to 50,000 psi. don't bother us either. We're rugged! We always give you accurate, fast, sensitive and stable temperature readings.

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WRITE TODAY FOR YOUR THERMOCOUPLE CATALOG TC — 11

More than 48 pages of profitable information on every type of Thermo Electric Thermocouples.

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*Ceramo® — Thermo Electric's ceramic insulated, metal sheathed thermocouple wire.

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey

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20 YEARS • *Temperature Measuring Systems and Components*

NEW PRODUCTS

characters per sec over telephone lines. A 8 x 3 in. CRT display will accommodate 10 lines of data with 72 characters per line. Up to 504 characters in any format can be used. The 2502 can also be a data entry device. Entire unit measures 12 x 12 x 22½ in. deep. Price: about $9,000.—Information Products Corp., Boston, Mass.

Circle No. 315 on reply card



NC TAPE VERIFIER

Motorized tape reader is used with this Flexowriter to prepare and verify codes in 8-channel tape to insure the accuracy of input coding for point to point or continuous path machine tool control systems. As a proof document is being typed on the Flexowriter, a tape is punched simultaneously. The document is then retyped from the tape, read by the motorized unit which is connected to the Flexowriter. If the assigned code does not match the code being read in the motorized unit, the punch will not perform. Code is compatible with standard EIA code for numerical control. Price: $3,920.—Friden, Inc., San Leandro, Calif.

Circle No. 316 on reply card

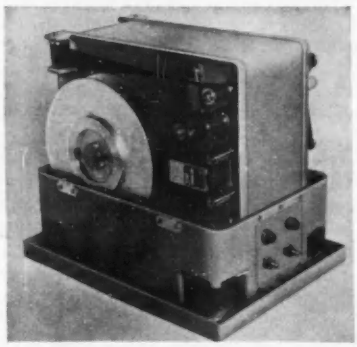


VERSATILE TAPE CONVERTER

This TMTC (Tri-Mode Tape Converter) is available in units to convert punched paper tape to magnetic tape, magnetic tape to punched tape, or punched tape to punched tape. The TMTC will accept and generate all

paper and magnetic tape codes now used. Paper tape data is read at 30 characters per sec and is converted to magnetic tape in seconds, or magnetic tape can be converted to paper tape for slower speed transmission. Editing functions can be programmed into the converter. A self-checking feature assures accuracy at each major step. Price: $80,000-100,000. Daystrom, Inc., Control Systems Div., La Jolla, Calif.

Circle No. 317 on reply card



PORTABLE DATA ACQUIRER

Unattended data acquisition over long periods is possible using this portable unit called the Type 6150 incremental digital recording system. Asychronous data is acquired by a tape stepping method that is described by the manufacturer as economical and dependable. One reel of tape will handle 38 hours of continuous recording at a stepping speed of 30 steps per sec. At lower sampling speeds one reel of tape may be made adequate for one year's unattended automatic operation. Only 8 watts of power is required so that two standard 12-volt batteries may be used. Price is expected to be about $9,000.–Minneapolis-Honeywell Regulator Co., Industrial Systems Div., Beltsville, Md.

Circle No. 318 on reply card

RESEARCH, TEST & DEVELOPMENT

PORTABLE TESTER

Rapid testing of aerospace synchro-transmitters is possible with this lightweight portable testing unit that provides accuracy formerly possible only with a master turntable, amplifier, and servoed indicator. High speed digital readout is provided on the panel of the 6¾ x 7⅞ x 10⅝ in. unit. The compact device, housed in a mahogany case weighs 12 lb. Price: about $3,500–



KEARFOTT VERTICAL-SENSING ELEMENTS

Two basic precision vertical-sensing elements are available, pendulous or bubble types. These devices can be applied to any vertical-sensing application requiring an electrical output indicative of displacement from gravity vertical. Sensing elements, employing electrolytic or electromagnetic pickoffs, are made in single- and two-axis types for either signal or power applications. A servo motor may be directly controlled by the power type for low-cost, moderate-accuracy applications. In addition to these proportional units, on-off switching devices are available. Precision leveling to a few seconds of arc may be accomplished with the signal types and external amplification.

The pendulous vertical-sensing elements employ a frictionless flexure suspended mass. Displacement from vertical, sensed about two orthogonal axes results in proportional phase-sensitive ac voltage outputs. The bubble types, of glass and noble-metal construction, contain an electrolyte and a gas bubble which acts as the gravity sensor. High reliability, low cost, and excellent resistance to vibration are achieved.

CHARACTERISTICS

	Part Number	Type	Excitation	Range	Null Repeatability
Pendulous	B1802-01	Electrolytic	400 cps*	1.3°	4 min.
	C70 1807 000	Electromagnetic	10 v 1000 cps	20 min.	4 sec.
	Part Number	**No. Axis**	**Type Output**	**Range**	**Null Repeatability**
Bubble	C70 1808 000	1	Proportional*	1° nominal	To 4 sec.
	A1800-01A-A	2	Proportional*	1° nominal	5 arc min.
	228571-1	1	On-Off*	Switches at 0.75°	Range 75-135 arc min.

NOTE: *Above designed for 400 cps., but higher frequencies possible. Excitation voltage is a function of circuit impedance.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

TRANSACTER

at BOEING

Remote source data collection — a bottle neck in Electronic Data Processing in many "big plant" operations — is no problem at Boeing's Transport Division, Renton, Washington.

We quote, in part, from *BOEING NEWS*, January 12, 1961: "The decision to install the entire network (TRANSACTER* System) came as a result of successful tests conducted . . . by Boeing employees and representatives of Stromberg, manufacturer of the entire system.

"Types of information that employees will 'feed' to the data collecting nerve center will include personal attendance data and detailed information of time spent on specific job assignments.

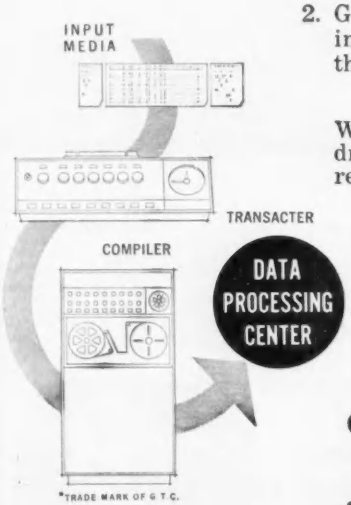
"The information will receive instantaneous treatment at the nerve center regardless of its origin.

"Some of the advantages of the system include the following:

1. Rapid gathering and processing of production information from factory shops. This data is vital in determining shop load and performance factors and in establishing accurate cost targets.

2. Greater accuracy in reports by reducing the margin of error caused through extra handling".

With the TRANSACTER System dramatic new opportunities for cost reduction become evident.



Write for informative brochure. If you prefer, a qualified representative will call.

GENERAL TIME CORPORATION

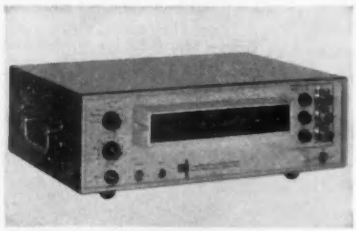
STROMBERG DIVISION
THOMASTON 7, CONN.

MAKERS OF THE WORLD'S FINEST TIME EQUIPMENT

NEW PRODUCTS

U. S. Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.

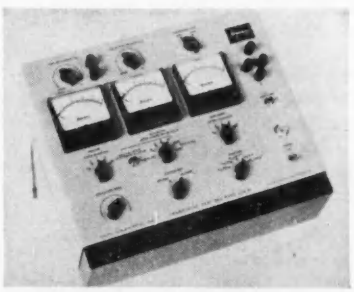
Circle No. 319 on reply card



100-MCPS COUNTER

Latest in the manufacturer's series of solid state counters, the Model 728B is the first 100-Mcps direct counting universal counter-timer. Unit measures and displays frequencies from dc directly without heterodyning techniques and measures time intervals and periods as short as 10 millimicrosec. A self-contained time base is used for counting. Paired pulse resolution is 10 millimicrosec, and long term accuracy is to within 5 parts in 10^8. All functions can be brought to the rear chassis, which makes the unit useful for automatic programming of control functions. Unit is priced at $3,950.–Computer Measurements Co., Selmar, Calif.

Circle No. 320 on reply card



H PARAMETER TESTER

Portable device shown above is designed for measuring hybrid parameters and leakage currents of small transistors and diodes. Currents of 7 ma dc and potentials to 70 volts are available. Dynamic tests at 1,500 cps are provided by an internal oscillator and ac millivolt reader. The following parameters of PNP or NPN junction or point contact transistors can be measured: h_{ib}, h_{rb}, h_{ob}, h_{fb}, h_{fe}, and I_{co}. Accuracy is to within 5

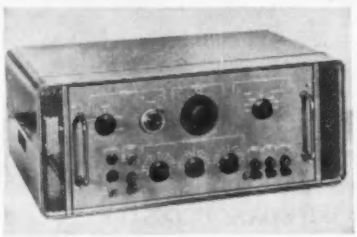
percent. Price: $550; an adaptor which protects surface barrier and other easily damaged types of transistors from small switch transients is $15.–Owen Laboratories, Inc., Pasadena, Calif.

Circle No. 321 on reply card

TRANSISTORIZED RECORDER

Transistorized circuitry is the feature of this rugged compact recorder that also boasts positive drive action, a built-in voltmeter, and a direct reading range dial. Manufacturer claims that this instrument is the most stable, noise-free, magnetic flowmeter ac potentiometer available. Included is automatic quadrature rejection. Price without primary magnetic meter: $800.–Fischer & Porter Co., Warminster, Pa.

Circle No. 322 on reply card



WIDE RANGE ANALYZER

Unique features of this newly developed electronic servoanalyzer include a wide frequency range for modulation and carrier frequency, electronic modulation, and inherent stability in both amplitude and frequency superior to that of similar instruments. For testing phase and gain response of servosystems, the unit provides modulation rates of 0.005-1,000 cps, in sinusoidal step and ramp functions. Carrier frequencies are 50-10,000 cps. Modulation frequency is accurate to within 2 percent of reading; phase measurement is accurate to within 2 deg. Price: $2,952.–Electronics Div., Chance Vought Corp., Dallas, Tex.

Circle No. 323 on reply card

PRIMARY ELEMENTS & TRANSDUCERS

SELF-CONTAINED ENCODER

Said to be the first Size 11 analog to digital shaft encoder to have all required logic circuitry contained within its own package, this ADC 11-11 unit uses both a 6-bit and 5-bit disc to obtain 11-bit capacity or 2,048-count





KEARFOTT SYNCHROS AND RESOLVERS FOR GIMBAL APPLICATIONS

Precision wound components for direct mounting to gimbal structures are now available for application in gyros, platforms and other devices. These components can be supplied with or without appropriate precision bearings.

A wide range of mounting configurations are available and special adaptations can be provided. High accuracy components, featuring maximum error of 20 seconds of arc are in quantity production. Improved accuracy can be provided as required. Materials used as housing can be either aluminum or beryllium weight reduction. Stainless steel housings for rigidity and corrosion resistance are available in many standard units.

Typical gimbal mounted components are tabulated below. Special units are available with beryllium housings and include two multipole (equivalent to 25 speed) units with accuracy of 12 secs/speed. The CZ 06311 001 is a synchro transmitter, the CZ 09623 001 is a combination transmitter-DC torquer concentrically mounted. A "piggy-back," two unit transmitter, one 3 wire the other 4 wire with stack height of 1" is also available.

SPECIFICATIONS

Typical Part Numbers	Size	Function	Excitation	Accuracy
325720	8	Resolver	2V 400 cps	15 min.
325721				
(Diameter .750". Length 1.250". See 3Z6390-001 below)				
3Z6390-001	25	Resolver Transmitter	20V 900 cps	3 min.
("Ring" housing–special hub designed to operate concentrically around a smaller unit.)				
CZ06360-002	As req'd.	Resolver Transmitter	115V 800 cps	20 sec.
(Pancake configuration beryllium housing 5.375" dia. X 1.437" high.)				
5Z6360-009	As req'd.	Resolver	115V 800 cps	3 min. or 5 min.
(Flat aluminum housing conforms to BuOrd 1980052-MIL-R-21530.)				
209981	23	Resolver	As required	10 min.
209984				
(High accuracy machined stack allows direct mounting without housing.)				
3Z6210-006	25	Synchro	As required	2 min.
(Various hub and housing configurations available.)				
1/3Z6360-006	As req'd.	Resolver	115V 800 cps	20 sec.
(High accuracy transformation ratio 1.0160 conforms to BuOrd 1980055.)				

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

NOW! IRIG TIME CODE GENERATOR

Output Signals in 7 Convenient Forms



The Hermes all solid-state Time Code Generator, Model 275 Type B, provides precision time signals (Days, Hours, Minutes, Seconds) in conformance with IRIG (Inter-Range Instrumentation Group) Recommendation No. 104-60, Formats B and C. Model 275 Types A and C, generate similar signals for other data recording and computer applications.

The chart (below) shows the types of time code data available and the seven forms of output presentation. Typical applications are illustrated.

FORMS OF OUTPUT PRESENTATION	TYPES OF DATA PRESENTED			TYPICAL APPLICATIONS	
	30 bit 100 pps	28 bit 2 pps	42 bit each ms		
(Serial) AM on 1 kc/s Carrier, 3-to-1 ratio	✔			High Speed Analog Tape Recorder	
(Serial) AM on 100cps carrier, 3-to-1 ratio		✔		Tape Recorders with speeds less than 7½ ips	
(Serial) D-C Pulse Width Code	✔	✔		Oscillograph	
(Serial) Neon Driver	✔	✔		Data Recording Cameras	
Parallel BCD			✔	Digital Acquisition Systems	

Pulse repetition rates of 1pps, 10pps, 100pps and 1,000pps are also provided.

The seven outputs of the Model 275 (6 serial, 1 parallel) are based on a built-in precision oscillator which is stable to 1 part in 10^8 per day. For those applications requiring even greater stability, the Hermes Ultra Stable Oscillator, Model 105A* may be switched in as an external frequency source. Circuits for automatic WWV synchronization with time preset are included. Also provided is a front panel Visual Decimal Display, synchronized with the output signals.

*Stable to 5 parts in 10^{10} per day!

Write for Technical Bulletin 275

Hermes

ELECTRONICS CO.

75 CAMBRIDGE PARKWAY, CAMBRIDGE 42, MASS.

A DIVISION OF Itek

NEW PRODUCTS

output. Accuracy is to within $\pm\frac{1}{4}$ of the least significant digit; 32 revolutions are required to obtain full count. Logic circuitry is binary, V-scan, and self-selecting, with silicon diodes for nonambiguous readout. – Guidance Controls Corp., Hicksville, N.Y.

Circle No. 324 on reply card



IMPEDANCE TESTER

Three force transducers and three accelerometers in the same plane are used to measure the impedance of mechanical systems accurately and conveniently. This gives a close approximation of force and acceleration at the same point. Nominal force sensitivity is 7 pk mv per pk lb; nominal acceleration sensitivity is 80 pk mv per pk g. Shown above mounted on the Model 2110 impedance head is the Model 2953 force generator which provides sinusoidal force over a wide frequency range for mechanical impedance studies. The impedance head is the puck shaped unit in the photo. Its price is $750.–Endevco Corp., Pasadena, Calif.

Circle No. 325 on reply card

LOW IMPEDANCE POT

Exceptional linearity and infinite resolution is claimed for this new potentiometer designed for low impedance applications. Trademarked Spiralohm, the Model 85176 is available with complete or partial turns from 1 to 10 with resistance from 1 to 10 ohms per turn with or without taps. Unit is linear within 0.025 percent. Life expectancy is 1 million revolutions.–New Jersey Div., Giannini Controls Corp., Caldwell Township, N.J.



INDICATES ANGLES

Designed primarily for military use in field testers, this angle position indicator is also suitable for a wide variety of commercial applications. The API, consisting of a servo indicator and an amplifier package, is available in six models with dual sensor units to measure angles from two independent sources. Accuracy is to within ±6 min with a sensitivity of 1 min, repeatability of 2 min, and resolution to within 1 min. Either vacuum tube or transistorized amplifier is available. – Kearfott Div., General Precision, Inc., Little Falls, N.J.

Circle No. 327 on reply card

PLUS . . .

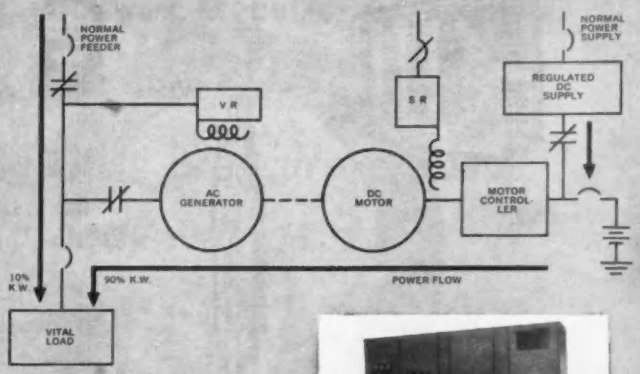
(328) **Taber Instrument Corp.,** No. Tonawanda, N. Y., has placed on the market a new **miniature transducer** for airborne applications involving gas pressures to 200 psig. . . . (329) The Model 4310 **solid state converter** is an accurate means for direct digital measurement of temperature and pressure now available from **Winsco Instruments & Controls Co.,** Los Angeles, Calif. . . . (330) Newly announced by **Motec Industries, Inc.,** Minneapolis, Minn., is a portable **analog to pressure converter** which will provide pressure and vacuum readings for flow through pipe lines.

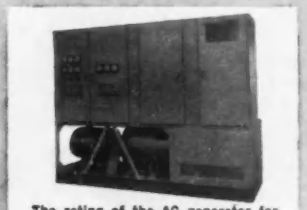
Circle No. 328, 329, or 330 on reply card

CONTROLLERS, SWITCHES & RELAYS

SWITCHES INPUTS

This 0.5 cu in. solid state low level switch, weighing 8 gm, is designed to switch input signals in a range of 0 to





The rating of the AC generator for this Kearfott system is 40 KW, 3 phase, 60 cycle, 460 volts.

CONTINUOUS UNVARYING POWER FOR VITAL INSTRUMENTATION IN CHEMICAL PROCESSING

A TYPICAL APPLICATION OF KEARFOTT UNINTERRUPTED POWER SYSTEMS

In chemical processes where even a split-second interruption of computers and related instruments can cause heavy losses, protection against power failure pays high dividends on a relatively modest investment. Take, for example, the Kearfott system pictured here, which assures surge-free entrance of emergency power in zero time in case the normal input varies or fails.

In normal operation, the DC motor runs continuously on power from the static supply, which also keeps the batteries fully charged at all times. The AC generator operates in parallel with the main power and furnishes about 90% of the vital load requirement.

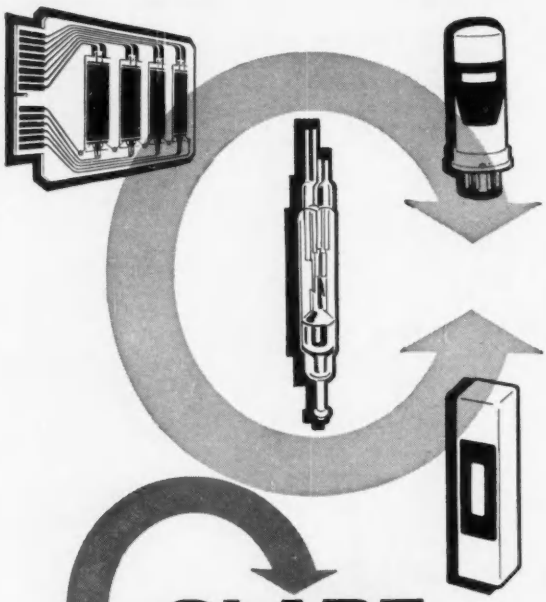
If the main power fails, the DC motor continues to run, drawing its current from the batteries. Simultaneously, the AC generator assumes 100% of the vital load. When main power is restored, the system automatically reverts to normal operation.

Kearfott systems are available with generator ratings to 150 KVA 60 and 400 cycles, single and polyphase, and provide frequency, voltage and transfer regulation as required by the application.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey



CLARE

Mercury-Wetted Contact Relays

. . . flexible to meet every requirement

Clare mercury-wetted contact relays are available in printed circuit assemblies, modules, conventional plug-in relays and special assemblies. Either of two basic switch capsules... HGS for especially fast, sensitive operation or HG for higher contact loads... is provided. These relays are tested for billions of maintenance-free operations. They never get out of adjustment, never bounce or chatter.

The Mercury-Wetted Principle

The remarkably long life of CLARE mercury-wetted relays is the result of a design principle whereby a film of mercury on the contacts is constantly renewed, by capillary action, from a mercury pool. Switches are sealed in a glass tube in high-pressure hydrogen atmosphere.

For complete data write for Design Manual 201-A

C. P. CLARE & CO., 3101 Pratt Blvd., Chicago 45, Illinois.
In Canada: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ont.
Cable address: CLARELAY.

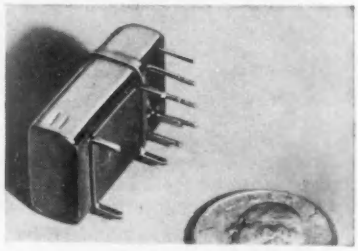
C. P. CLARE & CO.

Relays and Related Control Components

NEW PRODUCTS

±1 volt. Resolution is to 5 microvolts. Switching frequency can be from 0 to 1,000 samples per sec, and switching transient is less than 4 mv. No external transformer is needed. The SW-101 is priced at $164.78.—Alpha-Tronics Corp., Torrance, Calif.

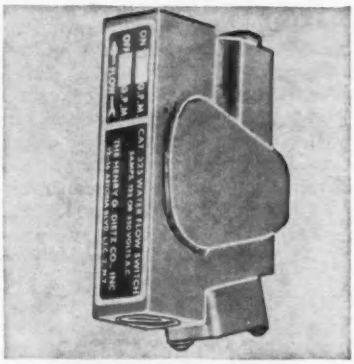
Circle No. 331 on reply card



FOR PRINTED CIRCUITS

Named Centipede, this high reliability microminiature relay is designed specifically for printed circuit applications. Only 0.44 in. high by 0.875 x 0.8 in., unit has 8 terminals and 4 mounting pins designed for standard circuit grid mountings. Relay is dpdt with contact life more than 100,000 cycles minimum at rated load. Both voltage and current sensitive models are available with coil resistances from 0.1 to 11,600 ohms. Device weighs 0.59 oz. Prices range from $11.43 to $20.45, depending on quantity.—Control Dynamics Corp., No. Hollywood, Calif.

Circle No. 332 on reply card

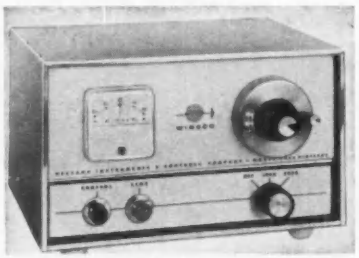


FLOW PROTECTION

This liquid flow interlock switch uses a moving Teflon vane in a bronze duct to sense flow and move a ceramic permanent magnet, which in turn actuates a snap action switch. For applications where fluid flow is a critical factor, the No. 325 switch features

low pressure drop, high current capacity, and shock and vibration immunity. Typical applications would be to protect fluid cooled tubes, transformers, and welding machines and in lubricating systems. Capacity is 5 amp, 250 vac; factory calibrated ranges of ½-6 gpm are available. Unit measures 3⅜ x 2¼ x 1½ in. Price, depending on quantity: $21.87-38.88.—The Henry G. Dietz Co., Long Island City, N.Y.

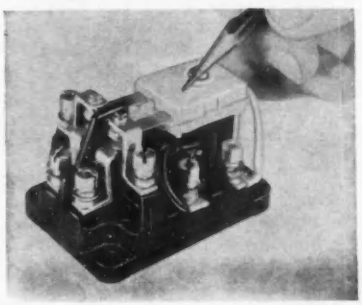
Circle No. 333 on reply card



DIGITAL CONTROLLER

Shown above is the Model 4050 Digitrol, a digital setpoint, on-off temperature controller. A platinum resistance temperature transducer is used with digital setting and display. Three-wire nulling bridge circuit provides a linearized setpoint, maximum stability, and freedom from line connection problems. Output is to a set of relay contacts which can handle from 2 to 15 amp at 115 vac. Red light indicates when temperature is below setpoint; nulling meter indicates deviation in degrees F. Instrument covers range of 0-2,000 deg F with repeatability to within ±2.5 deg F and resolution to within ±0.5 deg F. Price: $200.—Winsco Instrument & Controls Co., Los Angeles, Calif.

Circle No. 334 on reply card

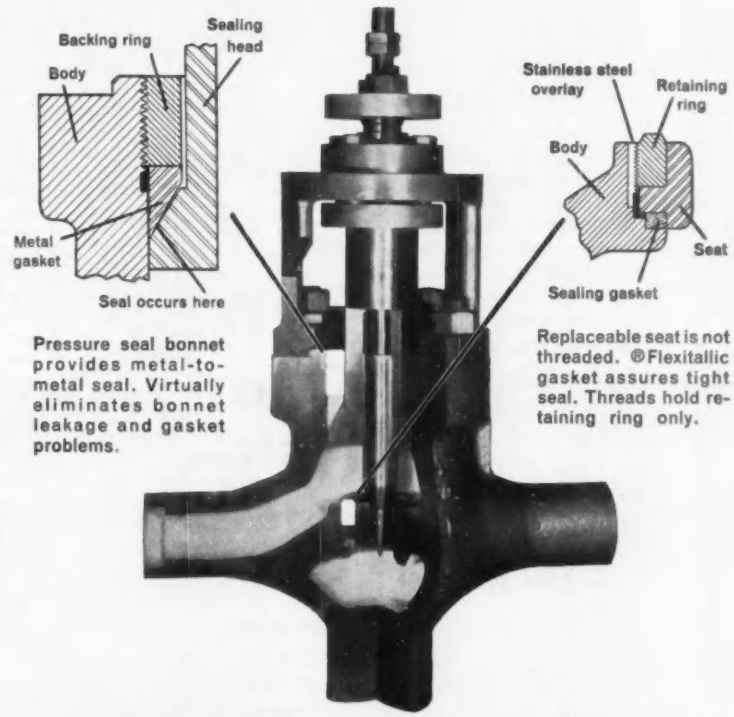


FOR INDUSTRIAL CONTROL

Intended specifically for industrial electronic control applications, this new line of multipole magnetically operated relays features compact low cost reliable design. All of these Nyline relays may be equipped with coils for ac operation to 230 volts max and

ROCKWELL-REPUBLIC

High pressure globe valve withstands pressure drops up to body ratings



Pressure seal bonnet provides metal-to-metal seal. Virtually eliminates bonnet leakage and gasket problems.

Replaceable seat is not threaded. ®Flexitallic gasket assures tight seal. Threads hold retaining ring only.

Rockwell-Republic high pressure globe valves are available in 1½", 2", and 3" sizes for 1500, 2500 and 4500 psi standards. In addition to removable seat and pressure seal bonnet, these valves are available with bolted bonnets and quick-change trim. For more information about this and other Rockwell-Republic components and systems, just mail the coupon below. RF-23

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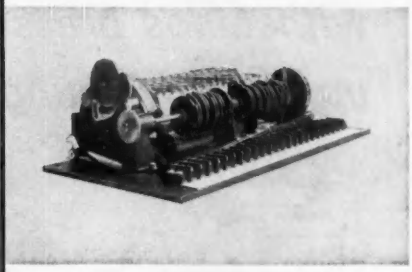
☐ Control Valves ☐ Process Transmitters ☐ Controllers
☐ Computing Relays ☐ Control Stations ☐ Recorders
☐ Flow Meters ☐ Drive Units ☐ V-5 Gauges
☐ Desuperheating & Pressure Reducing Systems
☐ Electronic Control Systems ☐ Pneumatic Control Systems

Name_____ Title_____
Company_____
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City_____ Zone_____ State_____

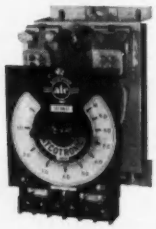
Republic Flow Meters Co. *(Subsidiary of Rockwell Manufacturing Company)*
2240 Diversey Parkway, Chicago 47, Illinois

TIMERS

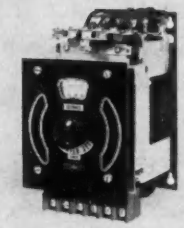
Multi-Circuit Cam Timers control sequence and duration of one or a series of operations. Time cycles from ⅔ of a second to 7 days. Controls 1 to 100 circuits in any length of "made" or "broken" periods desired. Choose either Repeat or Stop Cycle operation. **Series 2400**



Electronic Timers provide high accuracy and constant, exact repeatability for intervals from .02 to 120 seconds. Unaffected by vibration, tube aging, line voltage fluctuations. Printed circuit design, few mechanical parts mean long life at fast, repetitive cycling. **Series 5200**



Heavy Duty Reset Timers automatically and instantly reset on power interruption. SPDT heavy duty load contacts carry 25 amps. Available for vernier adjustment or cycle progress indication. **Series 2800**



Revolution Counters count shaft revolutions at speeds up to 1000 rpm, with only 1¼ oz. in. torque on input shaft. For measuring, product counting or cut-off, fluid metering, drill depth control, indexing, etc. Ideal where process variations occur and pulse count is not adequate. **Series 307**



IF IT'S A TIMING PROBLEM, SEE ATC. Wide product selection includes cam timers, automatic reset timers, revolution counters, electronic timers, impulse counters, transistor timers, many others.
Special timers and counters designed to your requirements.



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NEW PRODUCTS

dc to 115 volts max; two, three, or four-pole, double throw forms are available. Contacts rated at 10 amp are self-aligning and self-cleaning. The four pole model measures 2⅜ x 3¼ x 1$\frac{23}{32}$ in. List price for 4pdt unit: $21.20. —Ward Leonard Electric Co., Mt. Vernon, N.Y.

Circle No. 335 on reply card

POWER SUPPLIES

POWERS STRAIN GAGES

Low voltages for transistorized circuits and strain gages are provided by this highly regulated solid state supply. Working on an input of 105-135 vac, output is 0-10 vdc at 0-1 amp. Regulation is to within 0.002 percent for 10-percent line voltage change and 0 to 200 ma load current. Ripple is 1 mv rms max at 1 amp. Just 8⅜ x 10⅛ in., the Model PS 120 weighs 7 lb in an enclosure for bench use. Price: $350. Rack mounting units are available.—Dynex Industries, Syosset, N.Y.

Circle No. 336 on reply card

SUBSTITUTE FOR BATTERIES

The high degree of isolation achieved in the A4S series of isolated power supplies makes them suitable for use as low noise battery substitutes in bridge circuits, bootstrap circuits, and direct coupled dc amplifier circuits. Noise introduced is less than 10 microvolts peak-to-peak per kilohm impedance to ground. Regulation is by zener diode, and low ripple is featured. Output voltages from 6.8 to 200 volts ±5 percent are available. Units operate on 110-125 volts, 60 cps, measure 1⅝ x 2¼ x 3$\frac{7}{16}$ in., and sell for $36.50.—Elcor, Inc., Falls Church, Va.

Circle No. 337 on reply card

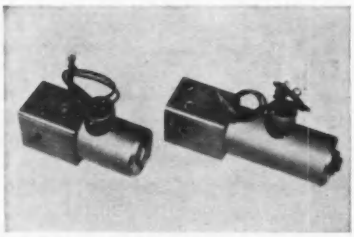
PLUS . . .

(338) Available from **Walter Kidde & Co., Inc.**, Clifton, N. J., is a Model S13 **static inverter** that supplies power to magnetic tape recorder synchronous motors. . . . (339) A compact 225-325 volt **regulated power supply** for 55-400 cps systems is priced from $55.50 by **Trans Electronics, Inc.**, Canoga Park, Calif. . . . (340) **Dynage, Inc.**, Hart-

ford, Conn., has placed on the market a $95 **constant voltage supply** for replacing batteries in laboratory potentiometers.

Circle Nos. 338, 339, or 340 on reply card

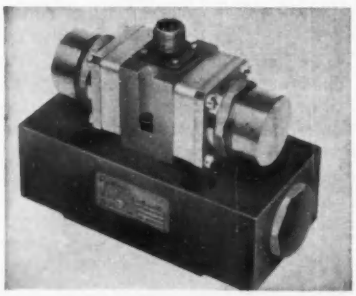
ACTUATORS & FINAL CONTROL ELEMENTS



DIRECTIONAL VALVE

These gasket mounted valves are said to be the only miniature hydraulic valves offered as four-way models in both single solenoid and double solenoid versions. This DIL Series is designed for small volume systems used in such applications as jig positioning in machine tools and venting on hydraulic system relief valves; a variety of spool types are available. Operation to 100 psi is possible; maximum capacity is 2 gpm.—Vickers, Inc., Div. of Sperry Rand Corp., Detroit, Mich.

Circle No. 341 on reply card



FOR AC AND DC

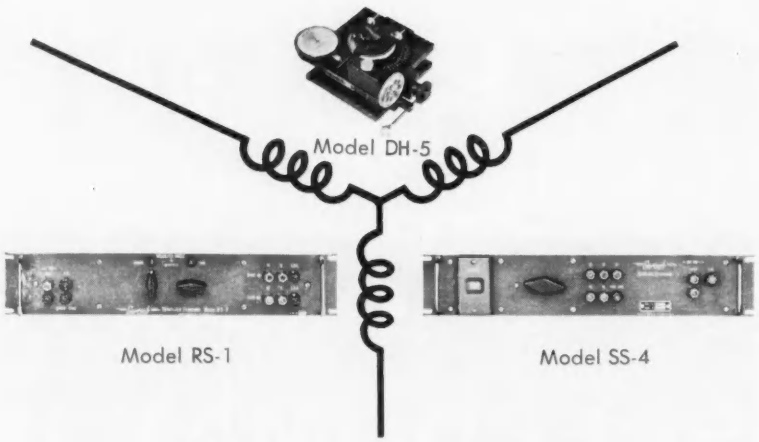
No adjustments or coil changes are necessary to convert this solenoid operated hydraulic valve from operation on 115 vac to 28 vdc. High performance valve operation on 60-cycle line supply or on emergency batteries is thus possible at a cost as low as single voltage valves. Assembly uses a solenoid operated pilot valve and a heavy duty slave valve designed for subplate mounting. Life greater than 5 million cycles at normal system pressures up to 5,000 psi is claimed for the device.

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SPEEDOMAX H THROUGHOUT INDUSTRY AND RESEARCH Again . . . and again . . . it's Speedomax® H–the first compact recording controller especially designed both for heavy industry and for research applications! Since its introduction over six years ago, enthusiastic users have ordered . . . re-ordered . . . and re-ordered . . . impressed with its basic excellence of design–its flexibility of operation–on thousands of applications both in production and in research.

For some of the reasons why it has gained such wide acceptance, see the following two pages. And for further information on Speedomax H, or on any of our products or services, call your nearest L&N office or write 4918 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP *Pioneers in Precision*



now...high accuracy synchro and resolver testing

— GERTSCH STANDARDS REPLACE COSTLY ELECTRO-MECHANICAL METHODS

Gertsch Synchro Standards simulate the output of a master Synchro Transmitter (CX), with better than 2 seconds of arc accuracy. Ideal for checking Synchro Control Transformers (CTs), or complete systems. Units feature a low effective unbalance impedance which permits loading the output without introducing stator output errors.

When driven by a suitable signal source, unit provides stator outputs S_1, S_2 and S_3, corresponding to the outputs of a master Synchro Transmitter as the shaft is rotated in 5° increments. Quadrant switching simulates operation over a full 360°. Series SS.

Gertsch Resolver Standards simulate the output of a master Resolver Transmitter (RX). Checks Resolver Control Transformer (RCT). Unit features low effective unbalance impedance, hence negligible loading error.

Driven by a suitable signal source, unit produces 2 isolated output voltages corresponding to the sine and cosine output voltages of a master Resolver Transmitter as the shaft is rotated in 5° increments. Full 360° operation. Series RS.

Synchro and Resolver Standards rotate throughout a full 360°, in 5° increments. Accuracy is better than 2 seconds of arc. Both single-switch and 2-switch models are available to cover all standard voltages and frequencies. Bulletins SS and RS on request.

Gertsch Divider Heads—for checking angular measurements on all types of rotary components. Accuracy is ±15 seconds. Repeatability: ±5 seconds. Large dial indicator provides direct readings with 3-second resolution. Unit rotates in 5° steps through a full 360° in either direction . . . is quickly set up, easy to operate, and fully portable. Bulletin DH-5.

Gertsch

GERTSCH PRODUCTS, Inc.,

3211 South La Cienega Boulevard, Los Angeles 16, California / UPton 0-2761 – VErmont 9-2201

NEW PRODUCTS

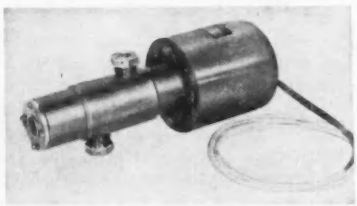
Valves for 400-cycle operation can also be supplied. Price from $100.—Parker Aircraft Co., Los Angeles, Calif.

Circle No. 342 on reply card

SELF-CONTAINED

This Model 410 servoactuator, which contains a servoamplifier, servovalve, and hydraulic cylinder, can be applied to machine tools and other special machinery requiring high performance positioning. The self-contained unit can be supplied with any stroke length from 1 to 6 in. and cylinder diameters of 1¼-2½ in. A power supply is also built in so command can be either by potentiometer or external electrical signal. Output thrust at full piston speed (40 in. per sec) can be to 5 tons. Frequency response is to 40 cps with 90-deg lag. Price: under $1,500.—Compudyne Corp., Hatboro, Pa.

Circle No. 343 on reply card



FIELD CHANGEABLE

This two-way solenoid valve can be converted in the field from normally open to normally closed without interchanging parts within the valve. Designed in an explosion-proof housing, unit operates on 110 vac, 60 cps and controls fluids or gases (including helium) at pressures up to 10,000 psi. Operating temperature range is −65 to +160 deg F. There is said to be low pressure drop at flow and no leakage. Quantity price: under $150.—Vinson Mfg. Co., Van Nuys, Calif.

Circle No. 344 on reply card

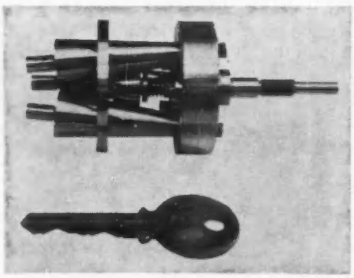
COMPONENT PARTS

FOR BRIDGE TRANSDUCERS

Only slightly larger than a package of king size cigarettes, the Model 96 RC contains a signal amplifier, transducer

power supply, bridge balance circuits, and calibration circuits. The unit can be used with any bridge-type transducer having one, two, or four active arms. Calibration circuits are remotely programmable, and four reference points are provided. Typical millivolt level transducer signals are amplified to ±5 vdc max. Output impedance is low enough (300 ohms) to drive high sensitivity galvanometers directly. Price: $968.–Video Instruments Co., Inc., Santa Monica, Calif.

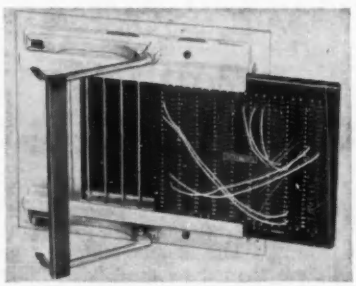
Circle No. 345 on reply card



MIDGET DRIVE

Highly accurate, this miniature variable speed transmission offers infinitely variable ratios for applications up to $\frac{1}{8}$ hp. Entire drive including precision lead screw control can be enclosed in the housing which is approximately $2\frac{1}{2}$x$3\frac{3}{4}$ in. long. Transmission is readily adapted for servomotor input and precision gear train reducer assembly. Drive is a compound planetary system with a track ring as the nonrotating member. Ring engages tapered rollers at varying diameters. Carrier for the rollers is transported by the input shift. Track ring is moved parallel to the lengths of the rollers to change speed.–Graham Transmissions, Inc., Menomonee Falls, Wis.

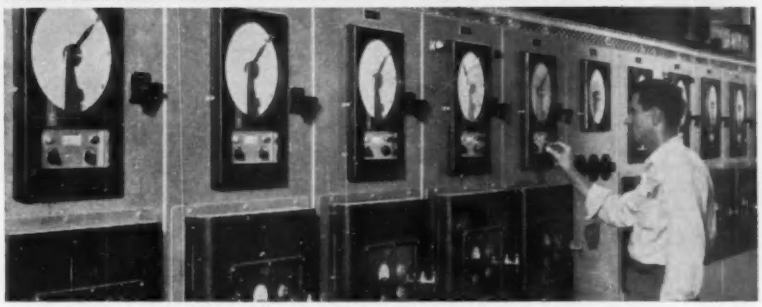
Circle No. 346 on reply card



PLUGBOARD PROGRAMMER

Large numbers of circuits within a system may be interconnected using this removable plugboard programming unit. This variable programming device uses a dual hub construction eliminating the need for busses, cum-

SPEEDOMAX H PERFORMANCE SPEEDOMAX H PERFORMANCE SPEEDOMAX H PERFORMANCE SPEEDOMAX H PERFORMANCE



Speedomax controlling temperatures of continuous annealing line.

PERFORMANCE-PROVED FOR INDUSTRY AND RESEARCH *When you specify any Speedomax® H, you get these basic features:*

Null-Balance Measurement—*combining potentiometer accuracy and electronic stability.*

Modular Construction — *plug-in components plus advantage-proved L&N positive drive with measuring-slidewire contact, control cams, etc., moving in permanent alignment.*

On-The-Job Economy—*reflected in low initial cost . . . simplified construction . . . accessible parts . . . minimum maintenance.*

Installation Ease—*simply connect leads . . . set control point setter . . . turn on power switch.*

Compactness—*only 12" (h) x 11" (w) x 11" (d) . . . or 17⅝" (h) with integral control unit. Saves valuable panel space.*

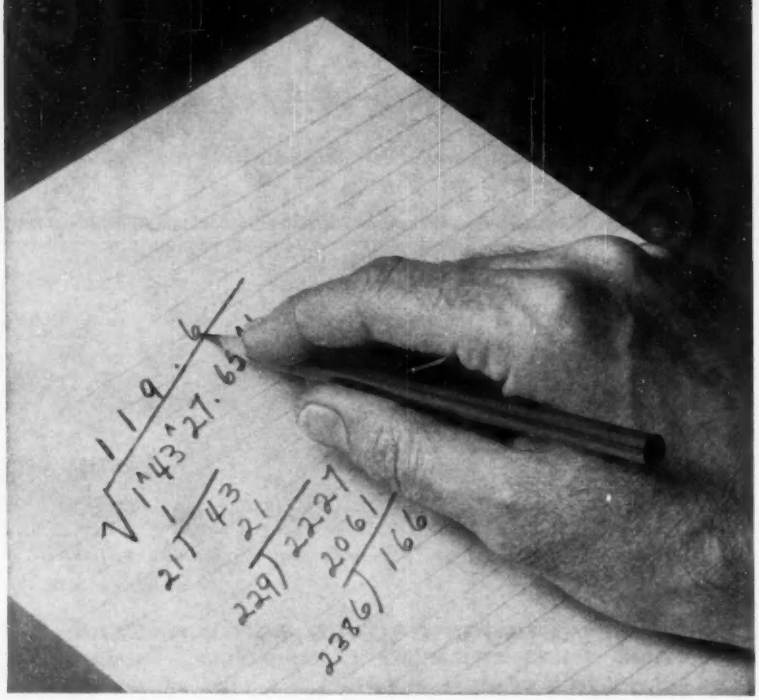
Quick Range-Change—*requires only a range-change card, a new scale and chart, a screw driver, and a minimum of your time.*

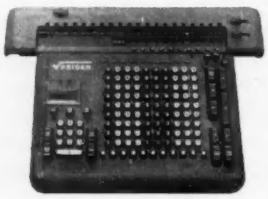
External Terminal Board—*with all wiring connections made at back of case.*

These are only some of the performance-proved features which are making Speedomax H the first choice in industry and research. For additional information on Speedomax H, or on any of our products or services, call your nearest L&N office or write 4918 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP *Pioneers in Precision*

Friden makes a desk calculator that does this automatically





The Friden Model SRW is the only calculator in the world that extracts square root at the touch of a key.

Because it does, a tedious, time-consuming job becomes as easy (and as quick) as entering the radicand, fixing the decimal point, reading the answer.

Because the time it saves generally belongs to high-priced people, the SRW will pay for itself even if used only a few times a day for square root. (The Model SRW is also a complete desk calculator in its own right, with all of Friden's time-saving features.)

Call your local Friden Representative for a no-obligation, ten-minute demonstration. Or write: Friden, Inc., San Leandro, California.

THIS IS PRACTIMATION: automation so hand-in-hand with practicality there can be no other word for it.

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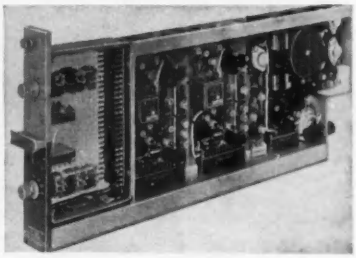
Friden

SALES, SERVICE AND INSTRUCTION THROUGHOUT THE U. S. AND WORLD

NEW PRODUCTS

bersome Y patchcords, and external connectors. The unit's 540 contacts function as a 270-pole, single throw switch. Reprogramming is accomplished in a few seconds by the insertion of a prewired plugboard. Unit price with one plugboard: $186.–Systematics, Div. of General Instrument Corp., Hawthorne, Calif.

Circle No. 347 on reply card



COMPACT AMPLIFIER

Offering a combination of characteristics not previously available in so compact a unit, the Redcor Model 500 single ended wide band dc amplifier is designed for instrumentation applications. Gain is adjustable from 10 to 1,000 and bandwidth, from 19 cps to 100 kcps. Input impedance is more than 1,000 megohms, and output capability is ±10 volts at 100 ma. Two single ended amplifiers use a common power supply in one package. Price: from $765 per channel.–Packard Bell Computer, Sub. of Packard Bell Electronics, Los Angeles, Calif.

Circle No. 348 on reply card

ACCESSORIES & MATERIALS

NONMAGNETIC PUNCH TAPES

These computer tapes are nonmagnetic and feature great endurance and capability of operating at high temperatures. The manufacturer's own adhesive is used to bond laminations of Mylar and aluminum and Mylar and paper. The tapes function perfectly at temperatures higher than 240 deg F and humidity up to 96 percent. Rolls of 1,800 ft are priced at $18-26, depending on material.–G. T. Schjeldahl Co., Northfield, Minn.

Circle No. 349 on reply card



PREVENTS CONTACT ARCING

A new series of eight subminiature mesa diffused junction silicon glass diodes has been designed as contact protectors to eliminate arcing and erosion across miniature relay contacts. The devices provide a maximum working voltage range of 30-300 volts with maximum coil current rating of 1.25 amp. The diodes are particularly useful under severe environmental conditions; operating temperature range is from −55 to +165 deg C. Price: $1.07-3.08. – International Rectifier Corp., El Segundo, Calif.

Circle No. 350 on reply card



AMPLIFIER FOR RECORDERS

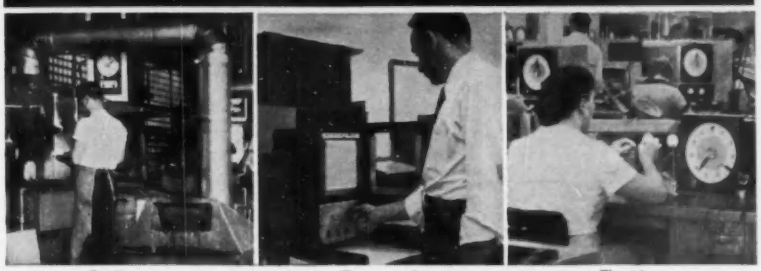
The 114 vacuum tube, chopper stabilized amplifier is designed to amplify the low voltage output of thermocouples, photocell devices, and other transducers for operation with the manufacturer's recorders. Gain is continuously variable so that inputs from 9 to over 45 mv will produce full scale deflections on the standard 1-ma recorder. Input impedance is 100 kilohms. Zero offset is approximately ±½ scale, independent of gain setting; drift and linearity are within ½ percent. Price: $110.–Rustrak Instrument Corp., Manchester, N.H.

Circle No. 351 on reply card

ADAPTS SINGLE TURN POTS

When coupled to a single turn potentiometer, this variable adapter changes

SPEEDOMAX H
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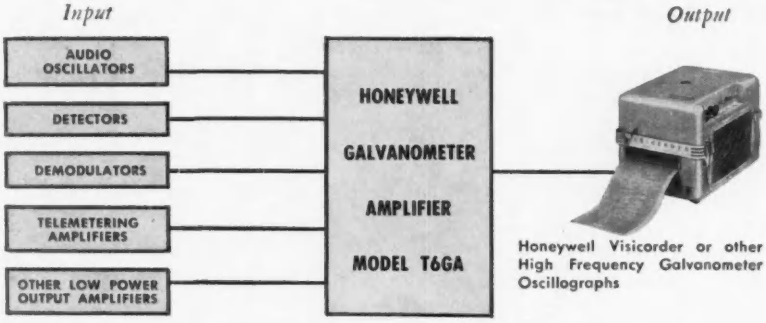
27 Other Optional Features *for versatility, convenience, safety.*

With such a wide choice of features, you can understand why industry and research are specifying Speedomax H not only to help them modernize present production, but to plan the products of the future. For additional data on Speedomax H, or on any of our products or services, call your nearest L&N office or write 4918 Stenton Ave., Philadelphia 44, Pa.

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GALVANOMETER AMPLIFIER

Strengthens Low Power Signals to Drive High Frequency Oscillographs



Honeywell Visicorder or other High Frequency Galvanometer Oscillographs



Galvanometer Amplifier. Model T6GA-1, measures 3½" high, 19" wide, 15½" deep.

DESCRIPTIVE DATA

VOLTAGE GAIN:
Adjustable from 0 to 1.0

OUTPUT (37 OHM LOAD):
±2.4 volts at 65 ma d-c to 8 Kc, limits at ±100 ma.

OUTPUT IMPEDANCE:
2 Ohms d-c to 10 Kc

CONTROLS:
6 GAIN controls, 1 Power ON-OFF switch

INPUT IMPEDANCE: 47 K

ISOLATION:
Individually floating channels for use with ungrounded loads

NOISE:
Less than 3 mv peak-to-peak

DRIFT:
Less than 3 mv/°F

POWER REQUIREMENTS:
115 volts ±10 volts, 50 to 440 cps, 45 watts

With Honeywell's new Galvanometer Amplifier, Model T6GA-1, high frequency oscillographs can now be operated directly by low power input sources of 1 volt or more. These inputs, some of which are shown in the diagram above, should have output impedances of 10 K or less although higher source impedances can be tolerated. Noise and drift are indistinguishable on the recorded output when the galvanometer-amplifier combination has a maximum sensitivity of 1 inch per volt.

The Model T6GA-1 is a compact, six channel, three stage transistor d-c amplifier with overload protection to eliminate both danger of transistor damage and galvanometer burnout.

Each of the six amplifier channels is isolated from ground by individual floating power supplies. Write for Bulletin BS-T6 to Minneapolis-Honeywell, Boston Division, Dept. 3, 40 Life Street, Boston, Mass.

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Industrial Products Group

NEW PRODUCTS

it to a multiturn unit, saving space and reducing assembly costs. Ratio adjustments up to 25 to 1 are possible. The unit is 1⅜ in. high and 2 in. in diam. Backlash is held to 0.5 deg max. Price: from $118.–Elm Instrument Corp., Hempstead, NY.

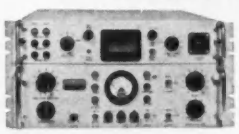
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PLUS . . .

(353) **General Electric Co.'s Silicone Products Dept.**, Waterford, N. Y., has developed a new group of self-bonded **silicone rubber compounds** and reinforced gums that provide a primerless bond to ferrous-containing metals stronger than that of the highest strength silicone rubbers. . . . (354) Now available from **Philips Electronic Instruments, Div. of Philips Electronics and Pharmaceutical Industries Corp.**, Mt. Vernon, N. Y., for use with its own and other manufacturers' diffractometers, is a high temperature, high vacuum attachment.

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over commercial telephone circuits equipped with Rixon's fully transistorized, low error rate, highly reliable Sebit-24 Transmitter-Receiver.

Binary information is processed 600/1200/2400 bits/second in a nominal 3-KC voice-band such as a long distance toll circuit. High speed data passage of: 3000 W/M teleprinters; machines and computers; slow scan TV; facsimile; time division multiplexers; and sequential telemetering equipment.

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- **Hot Gas Control Systems—III**
  Reaction forces correct vehicle attitude and orbit.
- **Computing Control Definitions and Concepts**
  Suited to summer reading, a blithe review in verse of a significant subject.
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CONTROL BITS

The USAF Minuteman solid fueled ICBM will use electrohydraulic integrated nozzle control units in each of its three stages to convert steering commands from the digital computer of its inertial guidance system into thrust vectors. Four position servos will be in each unit, one for each exhaust nozzle. The servoactuators and an auxiliary hydraulic supply will be tied to a common platform that serves as a manifold, component mounting structure, and base structure for the integrated, closed system.

•

Royal McBee Corp., which moved to Port Chester, N. Y. (suburban Long Island) in 1956, has found that the lower rent from Manhattan has not offset the increased costs of services, is planning to move back to the city. IBM Corp., on the other hand, is transferring a pilot group of headquarters personnel to its facility in White Plains, N. Y. (suburban Westchester county). If they work smoothly there, IBM may shift out of Manhattan.

hays



RAMBLINGS ON INSTRUMENTATION

MEMORANDUM

TO: President

FROM: Vice President—Sales

SUBJECT: DO FORMER MAJOR LEAGUE BASEBALL MANAGERS MAKE EFFECTIVE INSTRUMENT SALESMEN, PARTICULARLY WITH A NEW PRODUCT LIKE THE HAYS DISSOLVED OXYGEN ANALYZER?

I am not going to review all the steps that led up to the hiring of this old codger, Macey Bengle, who used to manage that big league ball club in the East. I admit I agreed at the time it was a charitable move in behalf of a nice old man who had been retired before he was quite ready.

However, the old gentleman has been on the road for two months now trying to drum up some interest in our new Dissolved Oxygen Analyzer—a red hot product if there ever was one—and I am gradually forced to the conclusion that baseball and instrumentation do not mix. Here, for instance, is a verbatim transcript of the sales talk this antique umpire baiter has been using:

"Now you take this here tank or pipe or thing in a situation like where the boiler feed-water could be getting the inside of the thing as rusty as Sal Maglie's arm and you've got to get the dissolved oxygen in there analyzed—although how the hell oxygen can dissolve in water is one for Judge Landis. So you go to the bullpen for the new Hays Dissolved Oxygen Analyzer in the clutch and it's right in there every time. Smaller than home plate, with a built-in calibration check they could use to replace umpires . . . and with a full scale range as low as 0 to 20 ppb it's as accurate as Whitey Ford with a no hitter goin'. Costs less to maintain than some of them ballparks in the Grapefruit League . . . gets rid of scrubbers, chemicals, tanks of gas . . . even hits to the opposite field. Does the trick with a galvanic cell with silver electrodes.

"Now if you folks don't want to pay cash, maybe we could get together on a little swap. How's about one Hays Dissolved Oxygen Analyzer for a shortstop who can hit and a left hander who can put out a fire in the late innings?"



Box Score on the Hays Model 625 Dissolved Oxygen Analyzer. Ranges: 20 to 100 ppb. Accuracy: 5%. Time Constant: 5 seconds. Sensitivity: 0.1 ppb.

This is not exactly the type of technical presentation our customers are used to.

However, it is not the jargon that I object to. The thing that's driving us nuts in the sales department is that this old boy is selling Hays Dissolved Oxygen Analyzers like crazy! He has sold them to every ballpark in the major leagues and when last heard from was starting on the Three Eye League. Our stock of spec sheet No. 625 on the unit is getting low and the morale of our sales organization is, frankly, going to pot.

So, as I see it our choice is clear: 1) we can send our elderly friend back to manage his bank and start selling dissolved oxygen meters the hard way, i.e., to power plants and the process industries, or 2) we can issue a plug of chewing tobacco to all our salesmen and become the biggest supplier of Dissolved Oxygen Analyzers to the baseball industry.

P.S. Also you might advise me what to do with the thirteen utility infielders and two sore-armed relief pitchers we have taken in trade.

MEMORANDUM

TO: Vice President—Sales

Sales are sales! Now get out there and pitch batting practice.

Phil A. Sprague

President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA



*The assembly shown above is part of a sophisticated system requiring the maximum in performance and reliability. It's typical of a SUPERIOR solution to a customers space problem. The engineering know-how of SUPERIOR in the field of servo-mechanics can add to the total capabilities of its customers.

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BULLETINS AND CATALOGS

The first four items in this section represent especially useful examples of applications literature. Direct request is required for the first three, and a charge is made for the first two items.

Semiconductor rectifiers

This 115-page handbook on semiconductor rectifier components is dedicated "to the harried power supply designer, the unsung hero of the electronic age". The attempt to aid him is well thought out and certainly worth the price of the volume. Besides tables of ratings and characteristic curves on the manufacturer's varied line of selenium, germanium, and silicon rectifiers, a basic introduction, definitions, "a rogue's gallery of transient voltage causes", test circuits, cooling fan and filter design, and other topics are included in the handbook sections of the book. A list of available applications literature and specification sheets is also given. Price: $0.50. General Electric Co., Rectifier Components Dept., Auburn, N. Y.

Nuclear projects

Completely revised since the second edition was issued last June, this 52-page compilation of fact sheets on U. S. nuclear power projects includes data of interest to those seeking to sell equipment for these jobs. Names, addresses of information officers and chief executives, methods of financing are among the facts listed. Also included is a short course in the U. S. approach to nuclear power development and in reactor classification. Price: $1.—Electric Companies Public Information Program, 230 Park Ave., New York, N. Y.

Instrument motors

Though it is built specifically around the manufacturer's line, this booklet is useful as a general guide to designing with instrument motors. Mechanical and electrical design features of the motors are described in the light of applying them to instruments. Techniques of mounting and of obtaining dynamic braking are covered, along with other topics. Complete tables of specifications and photographs round out the 26-page booklet.—Bodine Electric Co., Chicago, Ill.

Reference data

Fourth in this company's series of handy-sized reference handbooks (270,000 copies have already been distributed), this 32-page booklet contains tables and formulas, including weights and measures, math symbols and constants, Greek letters, electrical formulas, fundamentals of Boolean algebra, binary formulas, and many more subjects. —Industrial Products Div., Automatic Electric Co., Circle No. 400.

The next item requires direct request to the manufacturer.

TEST INSTRUMENTS CATALOG. Hewlett Packard Co., Palo Alto, Calif. 1961 catalog, 220 pp. Contains complete

description including specifications for the manufacturer's entire line of 400 test instruments. A section on applications data precedes each group of instruments, which are categorized by type or function. A 16-page listing of special systems and instruments produced by a company division is also covered. Three detailed indexes, ordering information, a bibliography of other available literature, and a list of other services are included.

CROSSBAR SWITCHES. James Cunningham, Son & Co. Bulletin 60-115, 20 pp. Entitled "High Performance Crossbars", this two-color publication can be used as a basic introduction to crossbar switching besides describing manufacturer's available equipment. Booklet describes two basic switching patterns (group to group and group to one) which may be actuated by three methods; all six basic types are covered. Photographs, drawings, tables, and curves complement the well-organized text. Circle No. 401.

ON-STREAM ANALYZER. Hagan Chemicals & Controls, Inc. Brochure, 14 pp. Describes the Chemonitor, an instrument that analyzes, on-stream, critical constituents in water. The device will continuously make any colorimetric determination made in a laboratory. Brochure lists features and operational data of the unit, includes price lists of the reagents and parts needed, and illustrates logging charts. Circle No. 402.

T'COUPLE REFERENCE JUNCTIONS. Genistron, Inc. Booklet, 8 pp. Details the Thermo-Ref constant temperature thermoelectric reference junctions for thermocouples of various materials. Typical schematic diagram and specifications are included. Circle No. 403.

PLANAR DIODES. Fairchild Semiconductor Corp. Catalog SL-201/4, 12 pp. New three-color publication describes more than 200 1N and FD series silicon planar diodes available from the manufacturer. Large size drawing describes the planar structure. Full tables of specifications, characteristic curves, and dimension drawings are included for all models. Circle No. 404.

BEARING HANDBOOK. Miniature Precision Bearings, Inc. Catalog, 64 pp. In addition to covering the 500 types and sizes of miniature and instrument bearings and other bearing products available from this manufacturer, this volume also serves as a technical handbook on these products. More than half the contents are devoted to chapters on bearing selection, materials, load ratings, torque and vibration testing, and lubrication, among other topics. A special section is included on nomenclature. Circle No. 405.

SEMICONDUCTOR SELECTOR. Accurate Specialties Co., Inc. Chart. Pocket-sized table aids in selecting the right alloy for alloying or soldering operations involved in semiconductor devices. Chart lists 56 different alloys in order of solidus and liquidus temperatures. Alloy is selected by referring to the temperature range desired. Some previously unpublished materials are included. Circle No. 406.

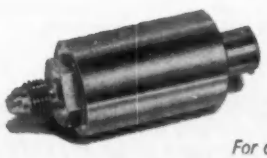
IN-CIRCUIT TESTING. Molecular Electronics, Inc. Booklet, 12 pp. Requisites of in-circuit testing, including considerations of semiconductor types, are cov-



SURPRISING!

Exceptional performance characteristics of Servonic's new H-160 high pressure transducer are particularly surprising considering the small size of this potentiometer type instrument. Its 1 by 1½ inch dimensions combine with rugged design and high resolution to make it ideal for military requirements where severe environments are a problem.

Utilizing Servonic's helical bourdon assembly, the H-160 is oil damped to furnish high accuracy and long life, even under vibrations exceeding 35 g. Superior linearity over the temperature range —65° to 275° F is provided in standard construction. Individual performance characteristics have been controlled to provide accuracies of ±1.0% error band in most ranges. The unit can be readily adapted to accommodate a wide range of exotic fluids.



For complete specs on the H-160 and its companion, low cost industrial unit, write for Bulletin S-605.

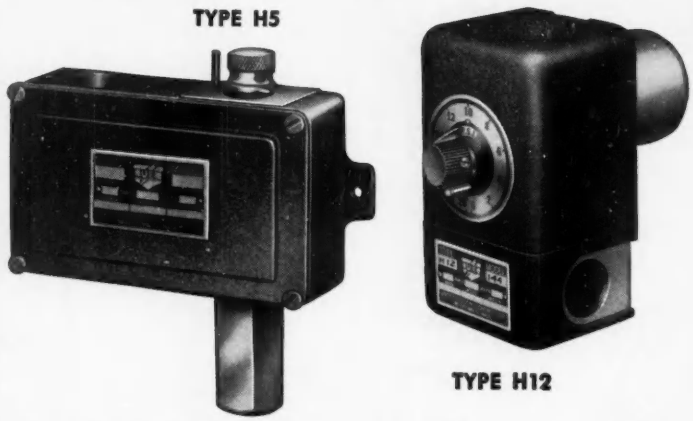
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External Adjustment & Calibration
on
PRESSURE & VACUUM CONTROLS **H5** **H12**

TYPE H5



TYPE H12

UNITED ELECTRIC designed these controls for industrial applications where outside adjustment and calibration are important factors. Types H5 and H12 accurately and sensitively control liquid level alarms and air gas pressures. The type H5 (minimum 2 psi differential) controls up to a maximum of 500 psi, and the type H12 (minimum 3" wc differential) up to 180 psi. Uncalibrated, internally adjusted versions of these controls are available as type J7 and type J6 respectively.

Switch Differential	H5 — Uniform on-off differential, fixed from 2 psi to 30 psi. H12 — Uniform on-off differential, fixed from 3" wc to 2 psi.
Switch Ratings	15 amps. at 115 or 230 volts AC, also 20 amps. or DC switches on specification.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Size & Weight	H5 — 5⅛" x 4⅞" x 1½" . . . weighs approx. 1 lb. H12 — ¾" x 2¾" x 5" weighs approx 1 lb. 6 oz.
Electrical Connection	Conduit opening in enclosure — ⅞" O.D. Internally-located terminal block.
Enclosure	Die-cast aluminum case with black wrinkle finish.
Mounting	H5 — Directly, by ¼" female NPT on bellows housing; or surface mounted by mounting ears on each end of case. H12 — Directly, by ¼" female NPT on bellows housing.
Bellows	H5 — Spring loaded, seamless brass, stainless steel or monel. H12 — Spring loaded, seamless brass bellows.
Pressure Connections	¼" female NPT.

UNITED ELECTRIC ***manufactures a complete line of temperature, pressure, and vacuum controls. UE will gladly modify or custom-build a unit to meet your specifications. Consult a UE application engineer today.***

For further information on these controls, write for Condensed Catalog # 500

UE®
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Bulletins and Catalogs

ered in this handy guide, which also describes the manufacturer's in-circuit test set. This is a basic go/no-go instrument that can test even the newer semiconductor devices. Data are given to show the effectiveness of in-circuit testing procedures. Circle No. 407.

PARTS CATALOG. Sterling Instrument Div., Designatronics, Inc. Catalog 65, 552 pp. Said to be the largest and most inclusive in its field, this latest electromechanical components catalog revision is divided into 67 product categories, including such products as speed reducers, clutches, brakes, differentials, and limit stops. Part numbers, lists, prices, specifications, and test reports useful in design work are presented within each category. Circle No. 408.

AVAILABLE STANDARDS. American Standards Association. Catalog. The association's 1961 catalog contains a listing of 1,973 American Standards. Included are listings of special publications in the standardization field, pamphlets, and standards recommendations of the International Organization for Standardization and the International Electrotechnical Commission. Circle No. 409.

CAPACITANCE CALCULATOR. General Electric Co., Wire and Cable Dept. Designed as a nomograph, this calculator, printed on laminated acetate, allows the design engineer to estimate electronic cable capacitance or conductor size and/or insulation wall thicknesses to meet capacitance requirements without using equations. Reverse side of the calculator carries information on cables and a handy chart of insulations. Circle No. 410.

MICROMINIATURE LOGIC. Fairchild Semiconductor Corp. Brochure, 8 pp. Describes the first in a series of Micrologic microminiature logic elements. A flip-flop will be followed by five additional types; this booklet covers its logic design and application. It can be used, for instance, to build a complete logic section of a digital computer. Circle No. 411.

TEMPERATURE RECORDING. Brush Instruments, Div. of Clevite Corp. Booklet Form No. TR, 12 pp. Describes how the manufacturer's universal carrier amplifier and a platinum resistance sensor are used to record temperatures from −220 to +2,000 deg F. Basic setup charts and full technical descriptions are included. Appendix covers temperature conversion and bridge linearity. Circle No. 412.

SPEED MEASUREMENT SYSTEMS. General Electric Co., Instrument Dept. Bulletin GEZ-3251, 12 pp. Covers company's complete line of ac and dc tachometer generators and indicators. Photographs and dimension drawings are included along with tables of specifications combined with price lists. A brief technical writeup covers application, calibration, accuracy, and ordering information. Circle No. 413.

DC SUPPLIES. Dressen-Barnes Electronics Corp. Catalog, 24 pp. Details on over 200 power supplies plus many kitted modules are included in this illustrated catalog. A special section is devoted to a designers' guide for engineers who calculate packing dimensions for multiple dc outputs. Circle No. 414.

COMPUTER SYSTEMS ENGINEERS

SALARY: TO $20,000

Several immediate openings exist at Hughes-Fullerton for Computer Systems Engineers qualified in the design and testing of large scale digital systems—and in the preparation of proposals for large scale digital computers.

These professional assignments involve such R & D areas as:

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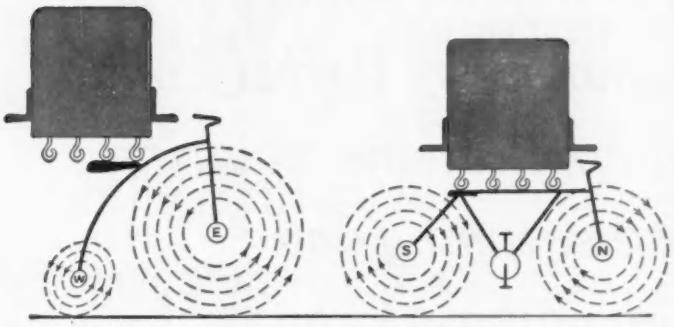
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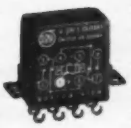


some relays are quite differential from others

If you want something to happen when a predetermined difference exists between two signals, gather 'round. Almost every* available subminiature dual coil "differential" relay we know of must have the "trip" signal applied to a specific coil and consequently the "reset" signal to the other coil. The dilemma stems from the lack of symmetry between the two flux paths or magnetic circuits of such a dual coil relay (the total pole gap changes with armature position). In a situation like this it takes more power to move the armature in one direction than the other, and when normal safety margins are added to operating power levels the disproportion becomes extreme. If you've found yourself with a relay that is this choosy about how and whether it transfers its contacts, you know you have anything but "true differential operation".

In typical and magnanimous fashion, we will now present *THE SOLUTION*, hoping that in due course it will also sell some of our relays. For true differential operation, without the pitfalls, we commend to your attention our subminiature Series 32 DPDT dual coil magnetic latching relay. The moment there's 100 milliwatts more on one coil than the other — regardless of how gradually the differential has taken place — the contacts transfer synchronously and completely. Hang up, blackout and those other monstrous contact mistakes often brought on by "sliding current" signals are neatly avoided by the design and adjustment of the "32". Its magnetic circuits and flux paths are as symmetrical as grapefruit halves, the gap remains constant no matter what the armature position, and essentially 100% cancellation occurs between coils. The 30 g to 5000 cycles vibration (operating or non-operating), 100 g shock and constant acceleration, and −65° to +125°C. operating temperature ratings all hold true for the stated 100-milliwatt sensitivity. Safety margins needn't be added just to make the specs hold true in practice.

* * *



If you've never used two collector circuits of a bistable whats-it to drive a dual coil polarized relay differentially, who knows what joys may await you? Write to Sigma today, telling us your differential troubles.

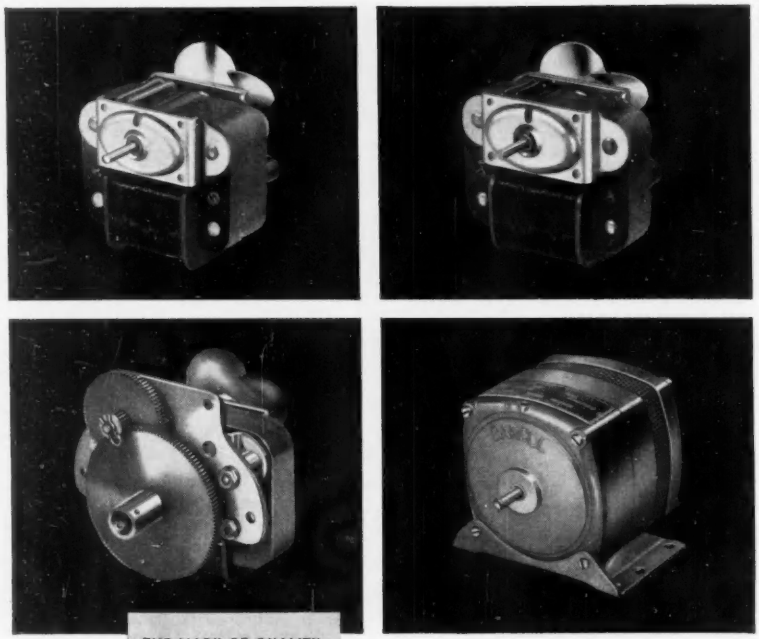
*Except ours, of course.

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CIRCLE 177 ON READER SERVICE CARD

Synchronous shaded pole a-c motors by Barber-Colman for applications requiring precise timing and high pull-out torque . . .



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a-c small motors

Developing 30 times the power of ordinary timing motors, Barber-Colman synchronous motors economically provide the dependability and long life necessary to many precision applications . . . such as X-ray timers, chart drives, scoreboard timers, oscillographs, facsimile recorders and many other industrial and scientific instruments. They synchronize rapidly and their high pull-out torque provides a reserve of power to maintain smooth operation during sudden load changes or fluctuations in supply voltage. Write for Bulletins M-5 and G-1.

3600, 60, or 1 RPM (STANDARD)

SPEEDS FROM 1/6 RPH TO 900 RPM AVAILABLE

RATINGS TO 1/25 HP

COMPLETE ENGINEERING SERVICE

UP TO 100 LB-IN. OF TORQUE

THE WIDE LINE OF BARBER-COLMAN A-C MOTORS includes unidirectional, synchronous, and reversible types . . . with or without reduction gearing . . . open or enclosed. Stator and rotor sets are also available. Write for illustrated quick reference file.

BARBER-COLMAN COMPANY
Dept. R, 1248 Rock Street, Rockford, Illinois

178 CIRCLE 178 ON READER SERVICE CARD

WHAT'S NEW

(Continued from page 45)

guidance from ESI, McKinney says the partner firms will help each other. "There will be frequent intercompany meetings where we will explore greater business possibilities." He shies from saying it in so many words, but it also stands to reason that greater sales between companies and to the Ling aircraft-electronics complex could result.

—Marvin Reid
McGraw-Hill News

NASA to Publicize Proposal Activity

Small control subcontractors will get a better chance to compete for business on National Aeronautics and Space Administration research and development contracts through NASA's new publication policy. The space agency will now list all proposed unclassified R&D contracts leading to prime awards of $100,000 or more in the Dept. of Commerce's daily Synopsis of U. S. Proposed Procurement, Sales, and Contract Awards.

A summary of each request for proposal and a list of the companies invited to bid will be included. In addition, the NASA information office and NASA field offices will make available the names of firms attending preproposal briefings and, after closing, those who have submitted proposals.

The synopsis, published since 1950, now goes to nearly 20,000 subscribers at $10 a year or $28 for air mail.

Japanese Seen Overproducing For Control Market

TOKYO—

A member of the American trade mission now visiting Japan told CtE here that he finds the Japanese instrument situation "explosive". In commenting on the Japanese' emphasis on production, Charles Schwarzler, vice-president of Foxboro Co. said, "My concern is that they will overproduce and won't have the sales techniques to sell what they make and then will resort to price cutting."

Japanese instrument makers "can beat us any time there is a fair amount of manual labor", Schwarzler added. But he was dubious about their ability to sell control equipment for U.S. plants. He pointed out the need for capital—in short supply in Japan—involved in programming for process control and also felt that the Japanese were not sufficiently acquainted with American manufacturing conditions to design equipment for them.

Commerce Reports Measuring Instrument Sales for 1960

U.S. manufacturers last year shipped approximately 3.8 million electrical measuring instruments valued at about $120 million, according to figures released by the Business and Defense Services Administration of the U. S. Dept. of Commerce. Around 17 percent of the total number of units or 35 percent of the dollar value went for military uses. Backlog at year's end was slightly more than 900,000 units or $31 million; this represents about three months' work. Following is a breakdown by major categories of electrical instruments.

TYPE	UNITS	VALUE ($1,000)
PANEL	3,487,834	60,521
Military	584,562	28,473
Nonmilitary	2,903,272	32,048
SWITCHBOARD	107,688	8,377
Military	17,182	1,166
Nonmilitary	90,506	7,211
PORTABLE	72,792	6,210
Military	11,212	1,394
Nonmilitary	61,580	4,816
RECORDING	99,168	43,636
Military	22,299	10,685
Nonmilitary	76,869	32,951

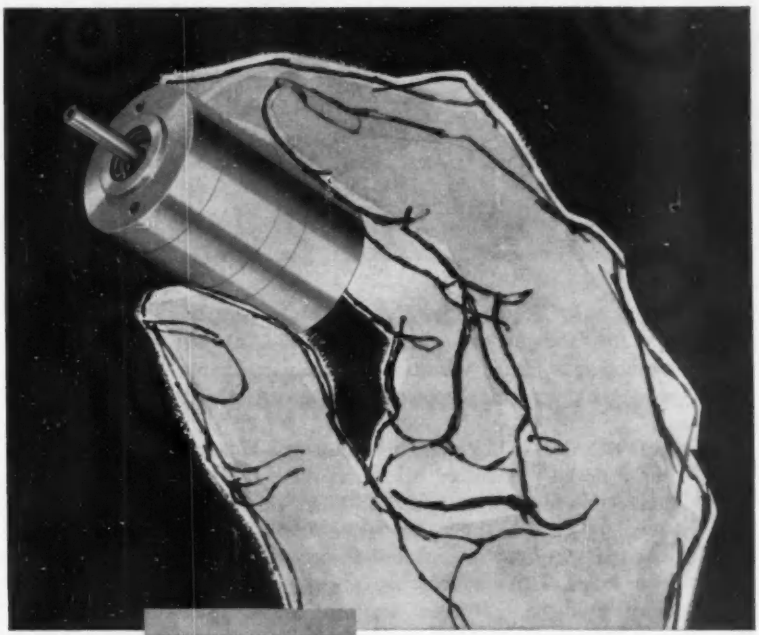
Capital Spending, Sales Survey Paints Hopeful Picture

Indications that the worst of the general business recession is now really past and, more important, that the business curve is pointing up for at least the next few years are contained in the recently released survey of business' plans for new plants and equipment conducted by McGraw-Hill Publishing Co.'s Dept. of Economics. Highlights of the survey:

► Investment by companies participating in the survey is now starting to rise after dropping sharply in the first quarter of this year. It may reach an annual rate approaching that of the record spending year of 1957 by the last quarter. Total for 1961 will be $35.7 billion. This means the year's investment will be off only 1 percent from 1960, representing a modest increase in plans from those reported in the preliminary McGraw-Hill survey last winter (CtE, Jan. '61, p. 38). And tentative plans (which generally grow greatly) indicate spending almost as high for 1962-64 as for this year.

► Manufacturing companies expect a modest (3-percent) increase in physical sales volume. The key to the companies' continuing investment lies in their expectation of a 20-percent

Type HYLM (1" diameter) Barber-Colman quality permanent magnet motor for precision applications . . . meets military specifications



THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

Type HYLM 1" diameter precision-made Barber-Colman motor is available in three lengths and can be supplied for use on any voltage from 6 to 115 volts d-c. Square brushes, retained by a constant-pressure spring, ensure long brush life. Dynamic braking can be employed if desired. This motor is equipped with R2 ball bearings, has an explosion-proof housing, and meets environmental requirements of MIL-M-8609 (ASG). A quality motor throughout . . . lightweight, compact, efficient. Ask for Bulletin F-10421.

typical applications

PROGRAM SWITCHES

TUNING MECHANISMS

ELECTROMECHANICAL ACTUATORS

COOLING FANS AND BLOWERS

TIMING MECHANISMS

SWITCHING DEVICES

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on the complete line of Barber-Colman electrical components, a-c and d-c small motors, tach generators, blowers, gearheads, relays.

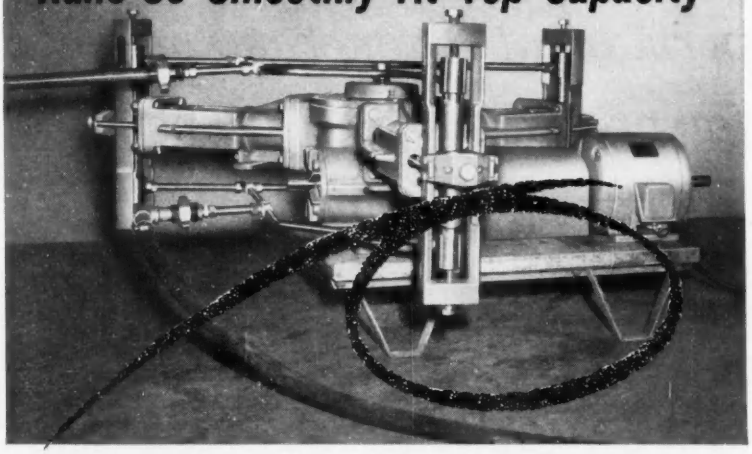
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CIRCLE 179 ON READER SERVICE CARD 179

NEW METERING PUMP

Runs So Smoothly At Top Capacity



You Won't Believe It's Not Anchored

Wallace & Tiernan's new Heavy Duty Metering Pump operates so smoothly there's no strain, no twisting or wrenching of parts. Vibration's scarcely noticeable — even when the pump's not fastened down.

This effortless action springs from a new idea in metering pump design: Balanced eccentrics drive the plunger and connecting rod in a straight line. There are no rocker arms.

This straight-line transmission of forces eliminates cantilever loads. Driving forces are absorbed by two heavy ball bearings in the gear case. The tendency to twist components loose from the base is gone. Perfect alignment, lifetime accuracy, and far less maintenance are assured.

The cancelling eccentrics, used in both stop- and run-adjust models, make stroke-length adjustment responsive and convenient — especially for automatic control. For safety, the drive mechanism is completely enclosed; for long life, it's force-feed lubricated.

All job-proportioned W&T Metering Pumps, Series 200, 400, and 600, have the same efficient design. Capacities range from 0.065 gph vs 4000 psi to 4050 gph vs 170 psi.

For other helpful features, write Dept. L-6.28

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

WHAT'S NEW

sales volume increase in 1961-64.

► Manufacturers are planning to devote 70 percent of their planned expenditures to modernization.

► Manufacturing plants operated at an average rate of 77 percent of capacity at the close of 1960, and increases are planned in capacity at a little more than 3 percent a year over 1961-64.

► Industry is continuing its emphasis on research and development. R&D will cost industry $10.5 billion this year, a 7-percent increase over 1960. The results of these efforts are expected to show up in new products, with 14 percent of 1964 sales made up of new items.

► The flow of investment dollars from depreciation will rise 8 percent in 1961 and another 16 percent by 1964. Cash flow—depreciation plus earnings—is expected to be up 9 percent this year.

Business' plans to update and modernize plants and equipment are always of great interest to instrument and control makers, since these spending intentions can be the bellwether of future sales. However, the industry group that includes instruments does not feel the need to expand to meet demand (see the chart below).

While this group indicated that it expected 1961 sales to grow 5 percent and 1961-64 sales to rise 22 percent—big figures considering the survey averages—the industry planned to spend 24 percent less this year than in 1960.

The tendency to increase depreciation may inject another note of good news for suppliers. Depreciation now pays for the bulk of capital spending by manufacturers.

BUSINESS' CAPITAL SPENDING PLANS

INDUSTRY	% Change 1960-61
Iron & steel	—26
Nonferrous metals	0
Machinery	+ 4
Electrical machinery	+ 8
Autos, trucks, & parts	+14
Aircraft, ships, & RR eqpmt.	— 5
Fabricated metals & instruments	—24
Chemicals	+ 4
Paper & pulp	— 9
Rubber	— 6
Stone, clay, & glass	— 5
Petroleum & coal products	+ 8
Food & beverages	+ 8
Textiles	—26
Miscellaneous manufacturing	— 2
ALL MANUFACTURING	— 3
Electric & gas utilities	+ 8
Commercial	+ 2
ALL BUSINESS	— 1

News of Other Companies In the Control Field

IBM Corp. has entered into a systems engineering agreement with **Allis-Chalmers** and its partly owned subsidiary, Consolidated Systems. They will provide EDP gear, basic equipment, instruments, respectively.

TRW Computers Co. now has an agreement with **Swartwout Div.,** Crane Co., to supply process control systems. TRW already has such a pact with Republic Flow Meters Co.

Smith-Corona Marchant, Inc., New York, and **Clary Corp.** have signed a preliminary agreement for the marketing of Clary's DE-60 computer. Clary will also continue to sell its machine.

Polarad Electronics Corp., Long Island City, N. Y., has completed negotiations for the acquisition of Federal Scientific Corp., a New York firm engaged in work involving long range detection and information theory.

Imm Industries, Inc., has been formed by Lewis W. Imm as his second venture since resigning as president of Librascope Div. of General Precision, Inc. last fall. Imm Industries, in Van Nuys, Calif., has started development of a high speed computer and a low cost dead reckoning system.

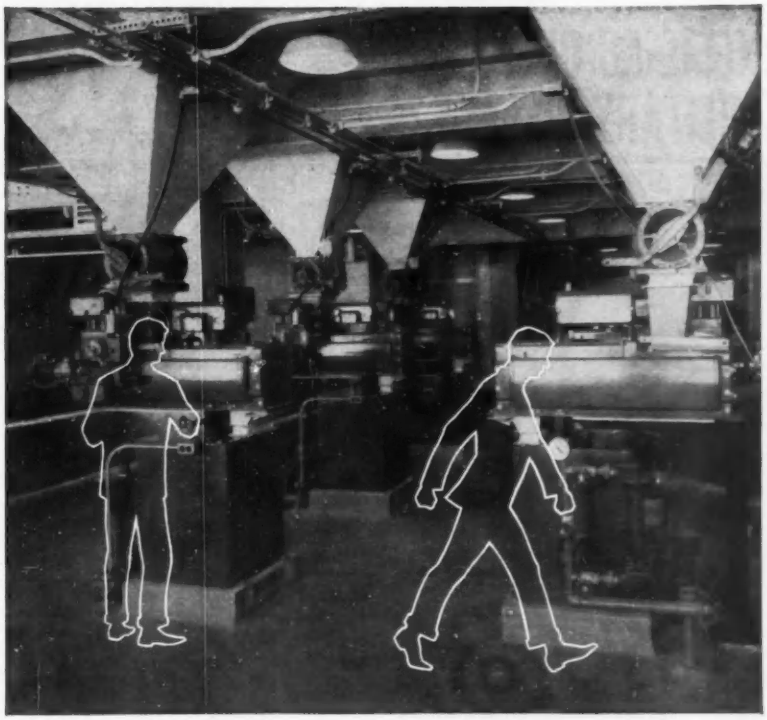
Sangamo Electric Co., Springfield, Ill. has acquired the controlling stock interest in a Hingham, Mass., delay line maker, Microsonics, Inc.

CompuDyne Corp. of Hatboro, Pa., has acquired two other Pennsylvania firms, Transweigh Co. and Automatic Measurement Corp. Both companies will operate with Weighing and Controls, Inc., a CompuDyne subsidiary.

New York Air Brake Co. has reached an agreement to merge B-I-F Industries, Inc. of Providence, R.I., a manufacturer of automatic flow control equipment, into its organization.

Penn Meter Co., a newly formed Philadelphia, Pa., company has acquired from the Burgess-Manning Co. the former Penn Instrument Div., a maker of flow measuring instruments and primary elements.

Measurement Systems, Inc. has been formed in S. Norwalk, Conn., by two engineers formerly with Perkin-Elmer Corp., John R. Yoder and Morton H. Mehr. The firm will concentrate on development of electro-optical and infrared equipment.



SET IT... FORGET IT...

THE W&T MERCHEN FEEDER

When your dry blending or batching process calls for accuracy hour after hour, you need Merchen Feeders. Wallace & Tiernan Merchens feed like clockwork without attention . . . never waver in even the most exacting use.

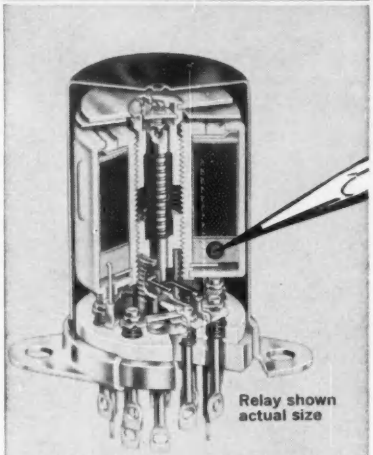
Their 0.1% sensitivity means that a change as small as 1 ounce in a 63-pound belt load automatically corrects the feed gate setting. You get continuous delivery at set feed rate. And you get true gravimetric feeding. Merchens are never affected by density changes. They self-adjust. You select the feed rate; the Merchen does the rest.

And Merchens give you the other qualities you look for in a feeder: minute-to-minute accuracy within ±1%, rigid, vibration-free construction, compact size, versatility. With Merchens you can control other dry or liquid feeders with pneumatic signals. Or you can use Merchens as slaves, responding to master signals.

For more information, write Dept. M-56.28.

WALLACE & TIERNAN INC.
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NEED AC-OPERATED MILITARY RELAYS?



Relay shown actual size

Rectifier circuits . . . full-wave bridge and half-wave . . . use highest quality miniature silicon diodes. Note potted construction.

For reliable switching . . . try "Diamond H" Series RA and SA relays with a-c coils

These relays for 400 cps and 60 cps operation are identical in size and weight to Hart's widely specified Series R and S d-c relays and meet the same specifications*. They provide the same shock resistance (to 50G), the same vibration resistance (to 20G-2000 cps), and the same performance under temperatures ranging from −65°C to +125°C. Contact ratings from dry circuit to 10 amps, 115 volts a-c resistive and 30 volts d-c resistive.

The "Diamond H" line includes hundreds of standard models and special variations are possible. Ask for literature and specification list.

*Like the R and S series, they meet the requirements of MIL-R-5757C. Models are also available to fill the requirements of MIL-I-6181.

THE **HART**

MANUFACTURING COMPANY
165 Bartholomew Avenue
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IMPORTANT MOVES BY KEY PEOPLE

Lewis Leaves Sylvania, Is New Perkin-Elmer Head



Robert E. Lewis has resigned as president of Sylvania Electric Products, Inc. subsidiary of General Telephone & Electronics Corp. to become president and chief executive officer of Perkin-Elmer Corp. He replaces Richard S. Perkin, president of the Norwalk, Conn., firm since its founding in 1939, who remains board chairman.

Lewis came to Sylvania in 1957 when it acquired Argus Cameras, Inc., of which he had been president since 1949. He then became a senior vice-president of Sylvania and was elected president a year later. He previously was with American Steel & Wire Co., Cleveland Wire Spring Co., and Batten, Barton Durstine & Osborn.

Esenwein Leaves Convair In Complete Reorganization

August Esenwein has left his post of executive vice-president of Convair Div. of General Dynamics Corp., as the result of a reorganization of GD that has brought on a complete change in the operations of Convair.

As originally reported in CtE (April '61, p. 200), the resignation of President J. V. Naish was not the end of changes for Convair. At the time CtE reported two plans were being considered for the reorganization of the division, which was a strong contributor to last year's GD loss of $27.1 million. One involved dropping the Convair general office in San Diego, Calif., the other meant splitting Convair into separate divisions. As now reported, parts of both plans are to be followed.

Convair will be split into five divisions, that will be known as General Dynamics-Astronautics, GD-Pomona, GD-San Diego, GD-Ft. Worth, and GD-Daingerfield. The Convair general office in San Diego will be eliminated, and General Dynamics will move its corporate offices from New York to San Diego, where it will be closer to 75 percent of its business.

These changes will result in a total of 13 GD divisions. The five new divisions plus General Atomic will be under C. Rhoades McBride, an executive vice-president who has been running Convair since Naish left. The other seven divisions, including the newly formed GD/Electronics Div. (CtE, Mar. '61, p. 202), will be in a group under W. P. Gullander.

Dr. Welkowitz Heads Gulton's Instrumentation Div.



New general manager of the Instrumentation Div. of Gulton Industries, Inc., Metuchen, N. J., is Dr. Walter Welkowitz. He succeeds Robert G. Day, who was recently appointed head of Gulton's activities in electro-optical scanning systems.

Dr. Welkowitz has been director of Gulton's Research and Development Laboratory since 1955; he will continue to manage the operations of this group. He has specialized in transducer design, industrial ultrasonics, and medical instrumentation.

Other moves in the Gulton division involved A. W. Orlacchio, who has been promoted to assistant general manager from chief engineer, and Daniel Abrams, who has become chief engineer from senior systems engineer.

Other Important Moves

Donald G. Fink has been named vice-president for research of Philco Corp. He had been director of research and general manager of the Research Div. Fink joined the Philadelphia, Pa., company in 1952 as director of research for consumer product programs; he was formerly editor of *Electronics* magazine and is a past IRE president.

Jerome D. Kennedy has joined Applied Dynamics, Inc. as executive vice-president and general manager. He joins the Ann Arbor, Mich., analog computer firm from a post as manager of engineering sales for Electronic Associates, Inc.

Robert H. Garretson has been elected president of Consolidated Electrodynamics Corp., a Pasadena, Calif., subsidiary of Bell & Howell Co. He succeeds **Philip S. Fogg,** who has become chairman and chief executive officer of CEC and vice-chairman of the B&H board. Garretson joined

PHOTOTRON



FIRST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile basic transducer offers incremental conversion of shaft angle to digital measurement. Available in seven models, its maximum permissible speeds range from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts, with sample rates ranging to 45,000 counts per second.

Applications for the Hydro-Aire Phototron include analog to digital shaft converters, precision analog servo with digital readout, data reduction equipment, tachometers, and precision measurement and control.

Detailed specifications are available on request. Related products soon to be available from Hydro-Aire, a member of the Crane Co. Systems and Controls Group, will include associated power supplies and binary and digital counters.

HYDRO-AIRE

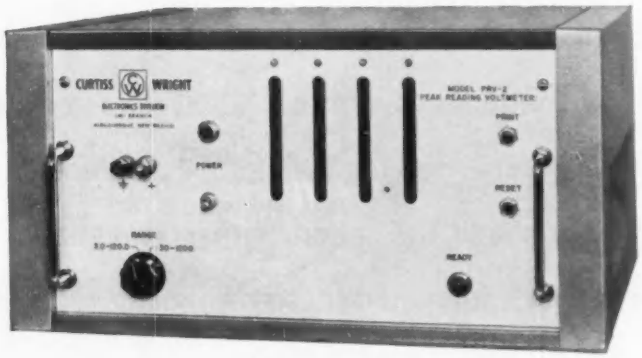
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Solid-state devices include time delay devices, voltage regulators, power supplies, inverters.

CIRCLE 210 ON READER SERVICE CARD

SINGLE TRANSIENT PEAK READING VOLTMETERS



Model PRV-2 Single Transient Peak Reading Voltmeter. Approximate size, 10½" x 20" x 15¾". Weight, 55 pounds.

Read single transient pulses with 1% accuracy

The Curtiss-Wright Model PRV-2 Single Transient Peak Reading Voltmeter reads out the peak amplitude of rectangular pulses of 25 microseconds or greater rise time to an accuracy of 1%. Rate of fall required to initiate cycle is 0.2 volts per microsecond on the 1200-volt scale and 0.02 volts per microsecond on the 120-volt scale. Read-out is provided, directly in volts, as a 4-digit decimal value. The first peak voltage detected blocks further input values until reset.

You can use Model PRV-2 for peak pulse measurement wherever an oscilloscope would be too inconvenient—or too inaccurate. It is perfect for blast studies, shock studies, spherics measurements, to measure any transient phenomena which can be characterized by a voltage pulse. Input range: 3-120 volts @ 200 Kohm, 20 uuf input impedance; 30-1200 volts @ 2 megohm, 20 uuf input impedance. And, of course, the PRV-2 can be modified to accommodate a variety of input requirements.

Write us about your needs.



SOLID STATE RELAYS for microsecond switching applications. Extremely resistant to high shock and vibration environments.

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SOLID STATE RELAYS • SINGLE TRANSIENT PEAK READING VOLTMETERS • TRANSISTOR TEST INSTRUMENTS AND SYSTEMS • DIGITAL DATA ACQUISITION AND PROCESSING SYSTEMS

CIRCLE 183 ON READER SERVICE CARD

WITH SO MANY OTHERS ON THE MARKET, WHY HAS BROOKS BROUGHT OUT A NEW LINE OF LEVEL TRANSMITTERS? Because no level control instrument now available can quite match (or even come close) to our new Series MPT level transmitters in overall capability. Brash claim? Not at all. Here, see for yourself: **1.** Independent transmission and indication, either pneumatic or electric, with optional alarm signaling and/or on-off control – all in a single instrument. **2.** Operation from either buoyant or displacer floats, with a buoyant-float range of 0-24 inches (nearly five times that of any other directly-actuated level transmitter). **3.** Linear or characterized output – can be square root or other exponential function. (MPT units can give a linear output from Parshall flumes and V-notch weirs.) **4.** High-pressure capability –standard models are rated at 1500 psi, can be made for working pressures to 50,000 psi. **5.** Adaptability – suitable for use with float mounted either within the vessel or in an external cage. **6.** Available in a practically unlimited range of wetted-parts materials for corrosive services.

Write for Bulletin 830

BROOKS INSTRUMENT COMPANY, INC.
5206 W. Vine Street, Hatfield, Pa.



BA-2326

184 CIRCLE 184 ON READER SERVICE CARD

WHAT'S NEW

CEC in 1959 as a vice-president responsible for the company's data processing divisions. He's been executive vice-president for the past 18 months. New Bell & Howell president is **Peter G. Patterson,** succeeding **Charles H. Percy,** now chairman.

Dr. Bernd Ross has rejoined the Semiconductor Div. of Hoffman Electronics Corp. in El Monte, Calif., as manager of the solar development section and assistant technical director. He is credited with developing the first commercial silicon solar cell.

Frederick J. Seufert has become president of U. S. Science Corp., an electronics manufacturer and a subsidiary of United Industrial Corp. located in Los Angeles. He succeeds L. D. Rexroat, who resigned. Seufert will also be president of another UIC subsidiary, Micro Path, Inc., which manufactures machine tool controls.

Louis P. Bosanquet has been renamed to a fellowship in instrumentation administered by the Foundation for Instrumentation Education and Research, Inc. The grant, donated by Foxboro Co.–all FIER fellowships are industry-donated–will be used at the University of Tennessee.

Ray G. Halvorsen, executive vice-president of Hamilton Manufacturing Co., was elected president of the Scientific Apparatus Makers Association at its 43rd annual meeting held in White Sulphur Springs, W. Va. He succeeds Dr. G. A. Downsbrough, president of Boonton Radio Corp.

Harry C. Anderson is the new president of the Office Equipment Manufacturers Institute and the first president who will serve on a full time basis, rather than as a member on an elective basis.

Conrad Kunze is now assistant general manager of the Otis Elevator Co.'s Defense and Industrial Div. in Brooklyn, N. Y. He has 20 years' experience in the aircraft and missile industry, including posts with Convair and Northrop Corp.

Dr. Nicholas A. Begovich, who was responsible for developing the three-dimensional radar system recently demonstrated by Hughes Aircraft Co., has been appointed a vice-president of the company. He is assistant manager of the company's ground systems group in Fullerton, Calif.

ABSTRACTS

Strip speed measurement

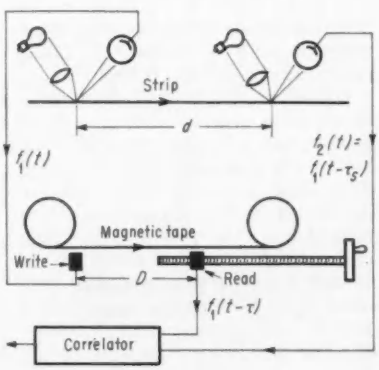
From "A New Method of Strip Speed Measurement Using Random Waveform Correlation", by M. H. Butterfield, G. F. Bryant, and J. Dowsing. Paper presented at a meeting of the Society of Instrument Technology, London, October 25, 1960.

The method of speed measurement described in this paper was suggested originally as a basis for the control of steel temper mills. It provides accurate comparison of the input and output speeds, does not involve contact with the material or assume any magnetic or electrical properties, and permits some lateral strip movement.

The figure illustrates the basic principle. Images of the electric lamp filaments are formed on the strip whose speed is to be measured, and photocells observe the light reflected at these spots. Because of surface imperfections the light received by the photocells varies with time, and the cells transmit electrical signals $f_1(t)$ and $f_2(t)$ that contain large random fluctuations. If the two filament images are placed in line so that the same parts of the strip pass through both, $f_1(t)$ and $f_2(t)$ are identical except for time delay τ_s.

A second delayed version of $f_1(t)$ is formed with a tape recorder or magnetic drum. As indicated in the figure, this delay τ can be adjusted by moving the read head on a lead screw.

By forming the cross correlation function of $f_1(t-\tau)$ and $f_2(t)$ and adjusting τ with the lead screw so that the correlator output is a maximum, the condition $\tau = \tau_s$ is obtained. τ is determined from the known tape speed and head separation D, and the strip speed follows from the known distance between filament images d.





NEW... DETAILED DATA ON SERVO MOTORS

Here's information you can use to increase speed and accuracy in high precision control and measuring equipment . . . 4 fact-filled pages on Holtzer Cabot's line of R-24 Servo Motors.

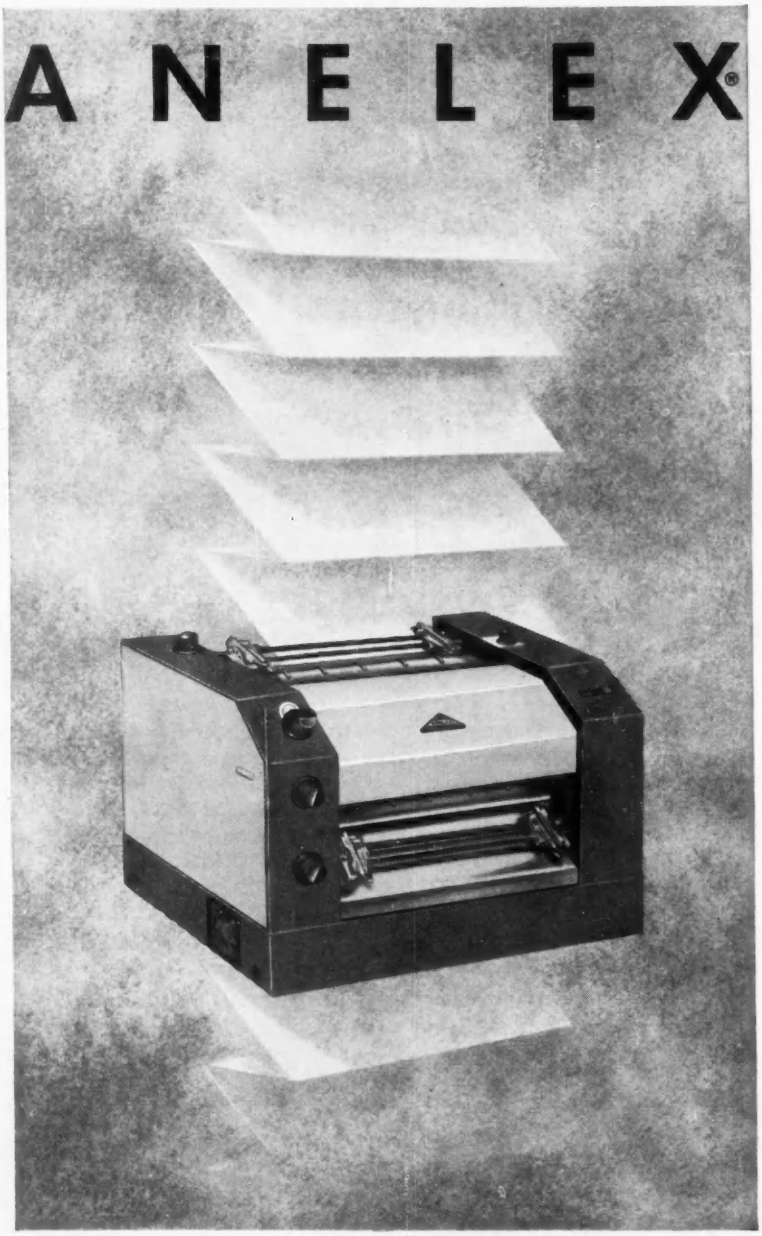
Contains 3 sets of speed-torque, performance curves: (1) For four different stator stackings with 115V on both windings. (2) For four different stackings with 115V on fixed winding and 200V on control winding. (3) For 0.7" of stator stacking with 115V on fixed winding and 200V, 100, and 50 on control winding. Gives additional data such as starting voltage, stall torque, rotor inertia, acceleration at stall, etc.

The R-24 Line has stator cores of 2.4" diam., available with stacking lengths of 0.5", 0.7", 1.0" and 1.4". Models with or without gear trains. Send for your free copy of Bulletin MO-3.7A. Write: Holtzer-Cabot Motor Division, 125 Amory Street, Boston 19, Massachusetts.

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MOTOR DIVISION
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CIRCLE 185 ON READER SERVICE CARD 185

Throughout the field of data processing Anelex High Speed Line Printers have established the standards of performance by which all other printers are judged, and only Anelex provides a complete range of models and performance characteristics



Further information available upon request

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ANELEX

186 CIRCLE 186 ON READER SERVICE CARD

ABSTRACTS

A resolving power better than 0.005 in. can be expected when strip is moving at 500 ft per min if the signal amplifiers, etc., have a bandwidth of 12.5 kc. With the filament images 15 in. apart this means a speed resolving power of 0.033 percent.

Simple addition and squaring is sufficient to find the peak of the correlation function. Manual control of τ is not satisfactory for continuous use, so a closed loop peak seeking control system was added. A servo motor geared to the lead screw moves the read head so that τ follows τ_x. Because the correlation peak is very narrow, a method of coarse read head positioning is essential. A system based on tachometer-generator measurement of strip speed was included.

Initial tests on a temper mill have produced the predicted results. The main difficulty has been precise adjustment of the optics.

New pneumatic hardware

From "Addition of Pressures in a Pneumatic Instrument with a Compensating Throttling Device", by Yu I. Ivlichev. Instrument Construction, June, 1960. Translated from Russian by Taylor and Francis Ltd., London.

The pneumatic adding devices used at present are complicated mechanical systems consisting of several diaphragm units. They are expensive, unreliable, and not sufficiently accurate.

Adding devices can also be based on the combination that takes place in flow chambers. When pressures are applied at the inlets to a chamber, then, under given conditions, the pressure established in the chamber is proportional to the sum of the applied pressures. If the correct throttling unit is chosen, it is possible to obtain an accuracy that permits employing these devices for practical addition. Throttling units that have linear flow characteristics can be realized by using capillaries of a certain length.

An adding device was constructed in the form of a disc 100 mm in diameter with 12 5-mm threaded axial holes. Holders with capillary throttling units made of medical hypodermic needles are screwed into 10 of these holes. The eleventh throttling unit is similar but its length is chosen so that, for a given range of the pressures being added and for a required accuracy, the flow chamber pressure does not exceed a critical value.



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with Harman-Kardon encapsulated digital logic modules... proven components...proven circuits...proven packaging

These fully encapsulated modules offer increased reliability—afford a high density, fully protected package with better heat dissipation. And, you will find the cost competitive with open card construction.

The modularized Series 200 logic circuits are available now—from stock—in a variety of logic configurations for operation up to 250 Kc. Higher speed units, too, are on the way!

The application engineering staff of the Data Systems Division stands ready to serve you in the implementation of your system block diagrams.

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CIRCLE 211 ON READER SERVICE CARD

TIME FOR YOU

TO DESIGN YOUR OWN TIMING SYSTEM WITH EECO'S DO-IT-YOURSELF COMPONENTS

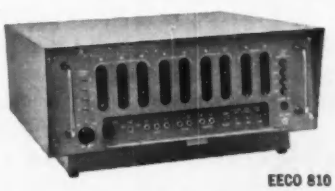
Now instrumentation engineers and test range management can build up their own precision timing systems with the convenience and economy of standardized, compatible, *all solid state,* off-shelf components. All standard time code formats available. Frequency stability, 3 parts in 10^8/day. Every EECO product is realistically priced for tight budgets. Prices include system design consultation by the leading developers of timing and synchronization instrumentation.

TIME CODE GENERATORS

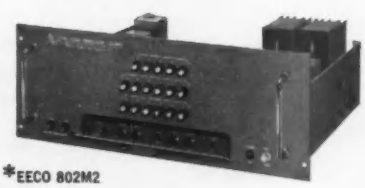
Model Number	Serial Code Format	Time Indication	Code Frame Length (SEC)	Code Scan Rates (PPS)	Code Carrier Frequency (CPS)	Auxiliary Pulse Rates (PPS)	Price (f.o.b. Santa Ana)
EECO 801	24-Bit, 24-hour, BCD	hours, minutes, seconds	1	25, 50, 100	1000	100K, 10K, 1K, 100, 50, 25, 10, 1	$7500
EECO 802 (Eglin AFB and Patrick AFB)	17-Bit, 24-hour, Binary	hours, minutes, seconds	1	20, 100	1000	100K, 10K, 1K, 100, 20, 10, 1	$7000
	13-Bit, 24-hour, Binary	hours, minutes, ¼ minutes	15	1	1000		
* EECO 802M2 (Atlantic Missile Range)	17-Bit, 24-hour, Binary	hours, minutes, seconds	1	20, 100	1000	100K, 10K, 1K, 100, 20, 10, 1	$7000
			20	1			
EECO 803	20-Bit, 24-hour, BCD	hours, minutes, seconds	1	25	250	None	$7500
EECO 804	20-Bit, 24-hour, BCD	hours, minutes, seconds	1	25	100 (mixed with 1000)	1 1pp10s 1ppm	$7925
EECO 810	36-Bit, 365-day, BCD (4 extra bits available for identification data)	days, hours, minutes, seconds	1	100	1000	None	$10,100
EECO 810M1 (IRIG Member C Format Modified)	23-Bit, 365-day, BCD (4 extra bits available for identification data)	days, hours, minutes, seconds	60	2	1000	10K, 1K, 100 10, 1, 1ppm, 1pphr	$10,100

Model Number		Price (f.o.b. Santa Ana)
EECO 860	**Neon Distribution Amplifier.** Accepts up to 3 pulse-width modulated signals from a time code generator to provide signals to drive camera neon lamps in remote sites.	$2500
EECO 861	**Relay Driver.** Accepts up to seven separate pulse trains or pulse-width modulated codes from a time code generator. Seven separate mercury-wetted relay contact closures to control external equipment.	$1200
EECO 863	**Line Driver** for transmitting 12 channels of carrier modulated timing signals over long distances.	$1975
EECO 27096	**Scanner Unit.** Accepts outputs from the EECO 802M1. Produces two 17-bit modified time-of-day codes in the format of the Atlantic Missile Range and one pulse rate output.	$5775

Compatible automatic magnetic tape search equipment is available for operation with each EECO time code generator.



EECO 810



*EECO 802M2

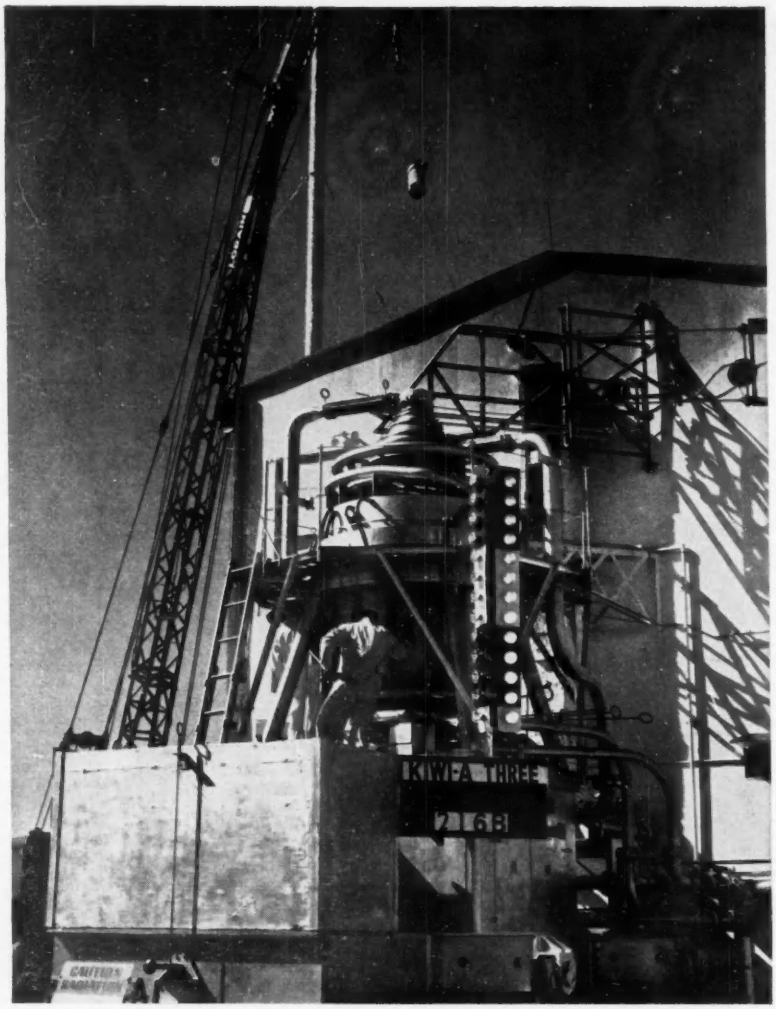
SEND FOR TIMING EQUIPMENT FILE 401, TAPE SEARCH FILE 201.

Electronic Engineering Company *of California*

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MISSILE & AIRCRAFT RANGE INSTRUMENTATION • DIGITAL DATA PROCESSING SYSTEMS • TIMING SYSTEMS • COMPUTER LANGUAGE TRANSLATORS • SPECIAL ELECTRONIC EQUIPMENT

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For employment information send resume to:
Personnel Director, Division 61-54A

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

ABSTRACTS

The device allows addition of up to 10 signal pressures, and when a zero level is introduced it can also subtract these pressures. Pressures can be added with an accuracy of 2 percent, and the response time is 0.1 sec. Sensitivity is practically unlimited. This adding device has started a new range of pneumatic instruments without diaphragms.

Stabilizing a satellite

From "Study of Systems Using Inertia Wheels for Precise Attitude Control of a Satellite," by John S. White and Q. Marion Hansen. National Aeronautics and Space Administration Technical Note D-691, April 1961.

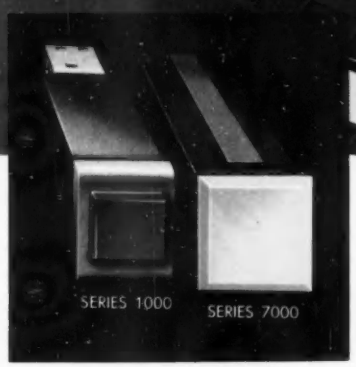
Many satellites require some form of attitude control; i.e., the satellite must be kept in alignment with a specified external reference or line of sight. The use of a motor driven inertia wheel to cancel disturbing torques is one of the more promising methods within the capabilities of present production. Three inertia wheel systems are analyzed in detail, using the Orbiting Astronomical Observatory (OAO) as an example. The three systems differ from each other only by the method of damping, which is provided by a rate gyro, an error-rate network, or a tachometer in series with a high pass filter.

An investigation including a generalized linear analysis, a nonlinear analysis using the switching time method, and an analog computer study shows that all three systems are theoretically capable of producing adequate response and maintaining the required pointing accuracy for the OAO of ± 0.1 sec of arc. Practical considerations and an experimental investigation show, however, that the system that uses an error-rate network to provide damping is superior to the other two systems. The system that uses a rate gyro is inferior because the threshold level causes a significant amount of limit-cycle operation, and the system that uses a tachometer with a filter is inferior because a device with the required range is not available.

The experimental laboratory apparatus used to investigate the dynamic performance of the systems is described, and experimental results are included to show that under laboratory conditions with relatively large disturbances, the dynamic tracking error is less than ± 0.5 sec of arc.

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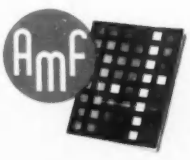
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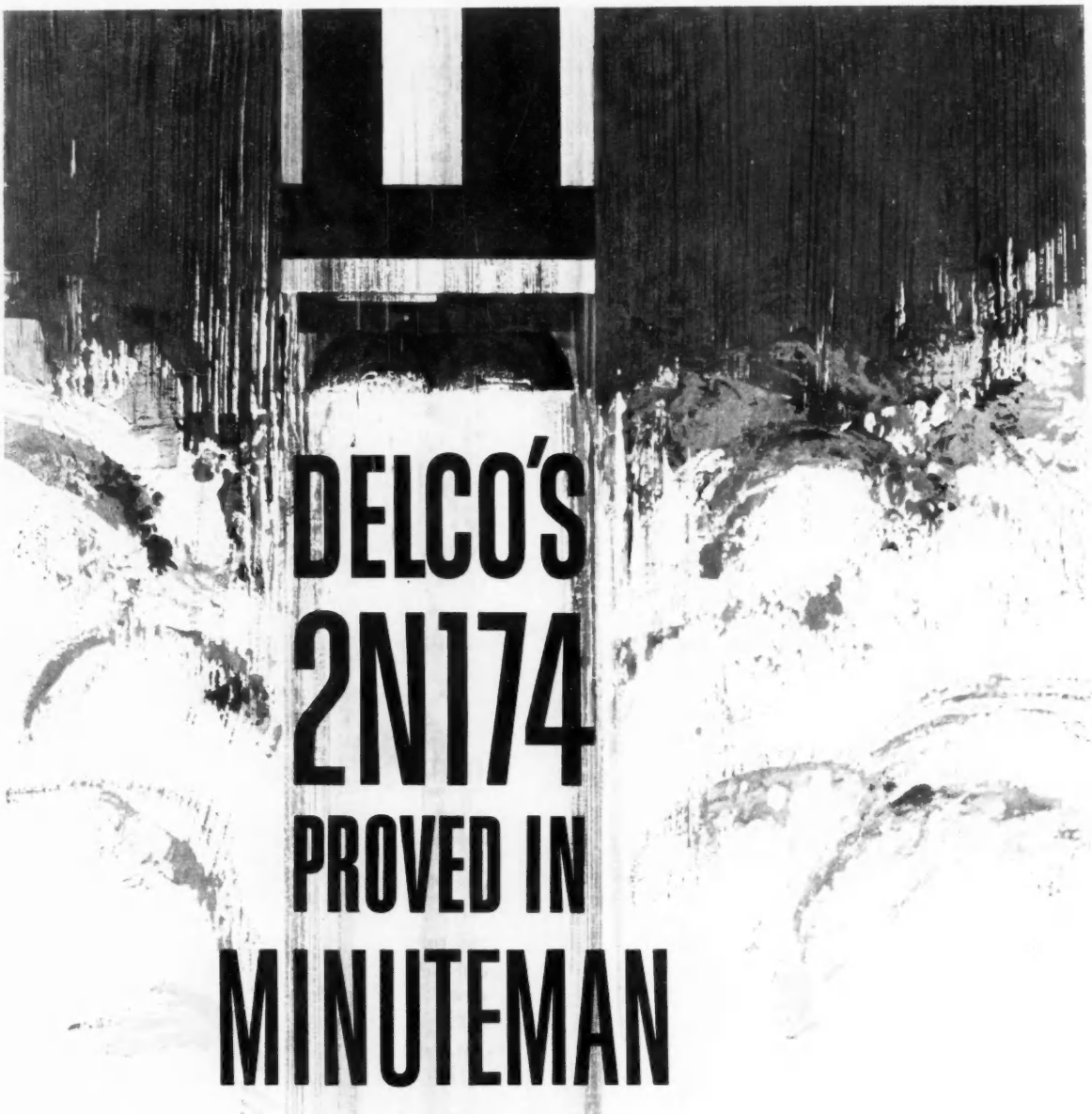
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Applied math trends

MODERN MATHEMATICS FOR THE ENGINEER (SECOND SERIES). *Edited by Edwin F. Beckenbach, 456 pp. Published by the McGraw-Hill Publishing Co., Inc., New York. $9.50.*

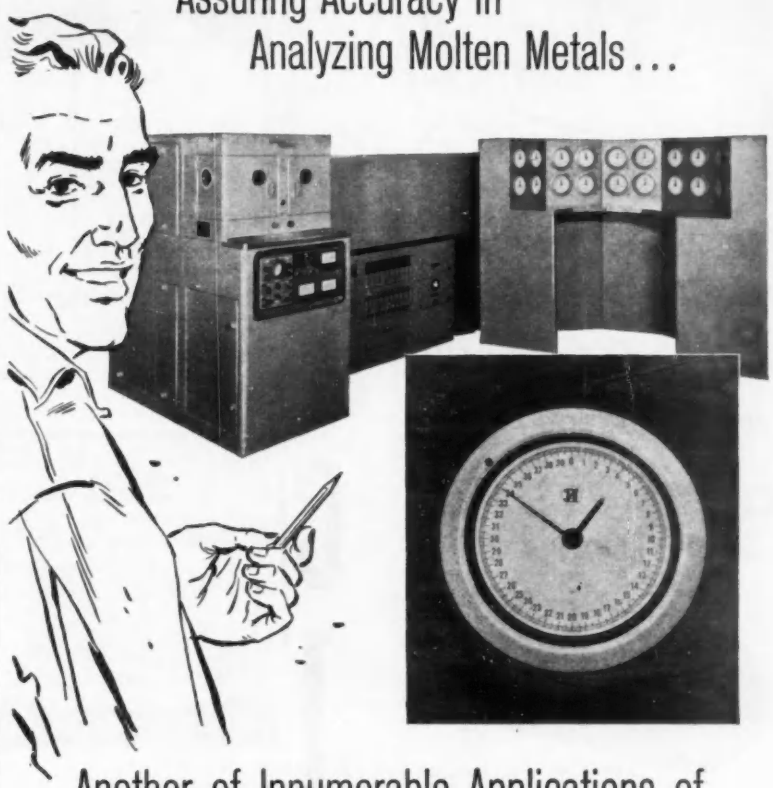
This is a carefully edited and coordinated collection of lectures by experts. Its purpose is to provide a perspective of some of the latest trends in applied mathematics for those engineers, scientists, and mathematicians who need such a broad view. It is neither a reference book nor a textbook (the subject material is not treated in sufficient detail for teaching or self-study). It provides a broad, conceptual view, points out specific tools (with many references) for those who have specific problems to solve, and points out areas in mathematics which are being explored to develop working tools. Any control engineer should find quite a few items that are of interest and one or two that he can put to use immediately.

Part I, Mathematical Methods, is concerned with tools such as delta functions, operational calculus, distributions, operators, integral transforms, semigroup methods, asymtotic formulas, and series. Some simple illustrations are given, but the lecturers are concerned primarily with the techniques and their history and development. These techniques are used extensively in Parts II, Statistical and Scheduling Studies, and III, Physical Phenomena. Part II covers chance processes, information theory, theory of control processes, linear programming, and theory of inventory processes. Part III is concerned with applications to relatively specific problems. These include Monte Carlo calculations in physics, difference equations and functional equations in transmission line theory, characteristic value problems in hydrodynamic and hydromagnetic theory, partial differential equations in fluid mechanics, numerical solution of elliptic and parabolic partial differential equations, symmetrization, and some classical physical problems.

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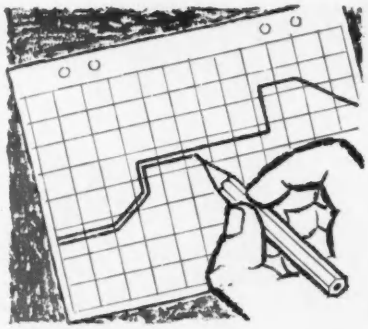


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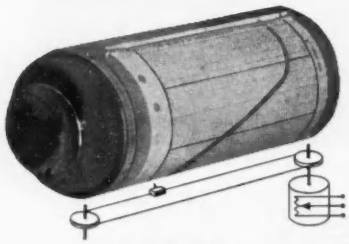
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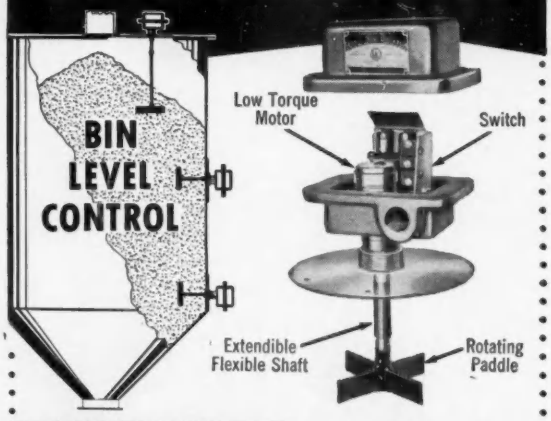
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Digital Computer Text

COMPUTER LOGIC. *Ivan Flores, 464 pp. Published by Prentice-Hall, Inc., Englewood Cliffs, N.J. $9.*

This is an elementary textbook on the logic of digital computers and their associated input-output equipment. It is written in sufficient detail to be read by one with no prior knowledge of digital computer design and only a basic background in undergraduate math and science. The topics are well illustrated by examples.

Of special interest is the detailed discussion of the logical design and mechanical construction of input-output equipment in Chapter 15. This includes lucid explanations of control consoles, input-output registers, buffers, and control units.

There are two major sections. The first explains the place of computers in science, government, and industry, and elementary systems analysis, programming, and coding. Coding is explained on an illustrative machine called Polyvac, a single address, decimal, drum storage type of computer with paper tape input-output. The second section develops the major theme: computer logic and design.

One of the appendixes contains a fairly complete glossary, and each chapter is followed by a set of illustrative problems. It is unfortunate for the reader without an instructor that the author did not include answers to some of these problems.

Frederick E. Wertz
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Inside gyros

AN ENGINEERING APPROACH TO GYROSCOPIC INSTRUMENTS. *Elliott J. Siff and Claude L. Emmerick, 120 pp. Published by Robert Speller & Sons, Publishers, Inc., New York. $7.50.*

The authors of this volume have successfully bridged the gap between the most elementary explanations of gyroscopic effects and the purely mathematical treatments. The first third of the book discusses basic gyroscopics—precession, gimbaling, nutation—and compares displacement, rate, and integrating gyros. Special gyro designs with reduced friction and vibratory and particle gyros are discussed, but only briefly. The rest of the book is devoted to instruments—vertical and directional gyro platforms.

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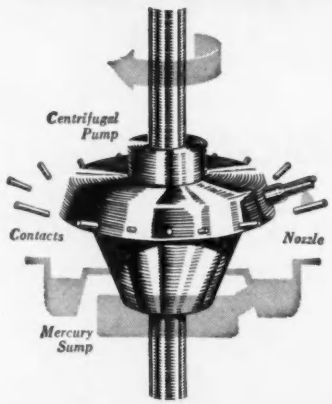
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Institution of Electrical Engineers, Conference on Components and Materials Used in Electronic Engineering, London, England June 12-17

Instrument Society of America, Third Biennial International Gas Chromatography Symposium, Kellogg Center, Michigan State University, East Lansing, Mich. June 13-16

Institute of Radio Engineers, Fifth National Conference on Product Engineering and Production, Sheraton Hotel, Philadelphia, Pa. June 14-15

Association for Computing Machinery, Computer Conference on Business Languages, Western Reserve University, Cleveland, Ohio June 15

American Institute of Electrical Engineers, Summer General Meeting, Willard Straight Hall, Cornell University, Ithaca, N. Y. June 19-23

Denver Research Institute of University of Denver, Eighth Annual Symposium on Computers and Data Processing, Elkhorn Lodge, Estes Park, Colo. June 22-23

Institute of Radio Engineers, Fifth National Convention on Military Electronics (MIL-E-CON 1960), Shoreham Hotel, Washington, D. C. June 26-28

IMEKO Conference, Engineering Societies Building, Budapest, Hungary June 26-July 1

Second Joint Automatic Control Conference, sponsored by IRE, ISA, AIEE, AIChE, ASME, University of Colorado, Boulder, Colo. June 28-30

JULY

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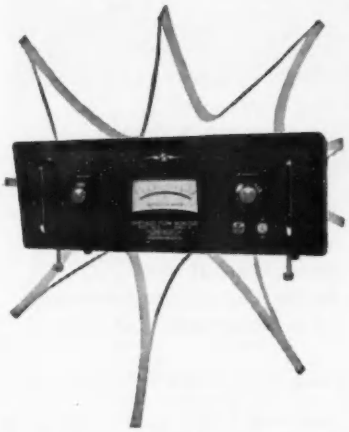
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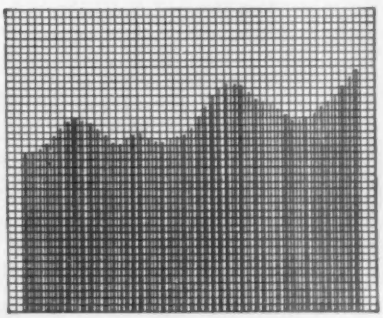
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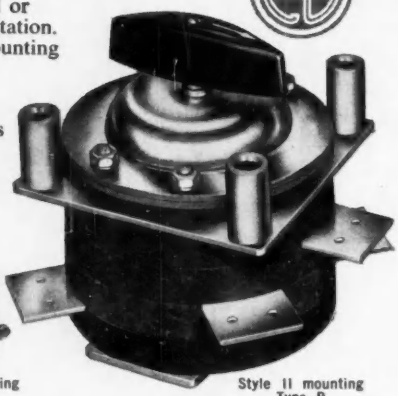
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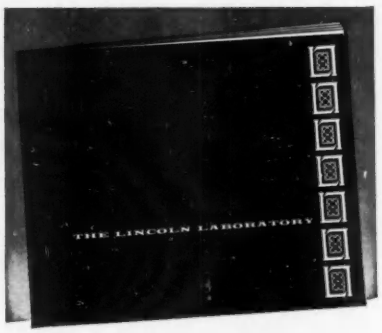
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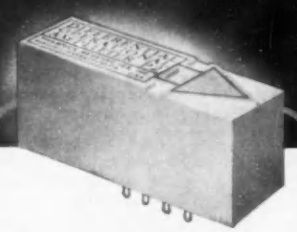
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502—Survey of Dynamic Display Techniques, 20 pp. The function of these newly developed techniques is to put up-to-date information in the hands of human operators of control systems when the information changes at a high rate. Both basic approaches and commercial hardware are discussed for cathode ray tube displays, optical systems, and miscellaneous devices ranging from TV pickup to matrix cells. 50 cents.

501—Six Transducers for Precision Position Measurement, May 1960, 6 pp. Explains operation and gives practical application hints for six precision position transducers: pin-and-pawl mechanism, magnetic bench-mark system, resolver-type transducer, electrostatic transducer, coded-disc devices, and diffraction gratings. 30 cents.

500—Ready Reference Data Files—I, II, III, 76 pp. The feature here is a special rate for those who purchase all of the Data Files published in CONTROL ENGINEERING through April 1960. The 36 articles included in this package cover analysis, design, and application short-cuts for all phases of the control field. Everyone can use this timeless reference material. $1.35.

499—Ready Reference Data Files—III, 28 pp. Includes the third dozen Data

(Continued on page 199)

New Philbrick 6033 solid-state power supply



BALANCED OUTPUTS, COMPUTING GRADE. The 6033 is the latest addition in the distinguished line of Philbrick power supplies. It will energize at least 10 Philbrick P2 amplifiers and other transistorized electronic equipment. Like the P2, its remarkable characteristics speak for themselves. *Low internal impedance:* less than 2 milliohms. *Low noise and hum:* guaranteed less than 150 microvolts rms (0.001%). *Highly regulated outputs:* against load, less than 300 microvolts; against line, less than 200 microvolts. *Low long term drift:* typically 0.1%. *Short transient recovery time:* no load to full load, less than 1 millisecond. *Unique short circuit overload protection:* inherent in the 6033's design with no extra circuitry to deteriorate performance. *Truly low cost:* about half that of supplies with comparable performance: **$285.**

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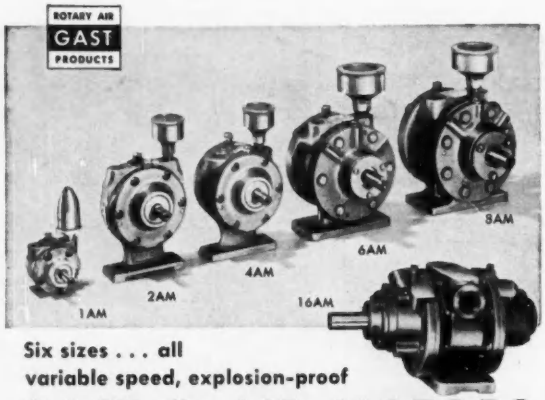
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6AM	2.0	17
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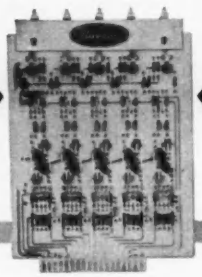
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Files published in CONTROL ENGINEERING. Topics range from control of metal properties with eddy currents to electrically signaled valve actuators to stabilization of sampled data systems. 60 cents.

498—Ready Reference Data Files—II, 24 pp. Includes the second dozen data files published in CONTROL ENGINEERING. Topics covered range from analyzing hydraulic servos graphically to using silicon diodes as protective devices. 50 cents.

497—Ready Reference Data Files—I, 24 pp. Includes the first 12 data files published in CONTROL ENGINEERING—a diversity of topics from system reliability through the cost of industrial temperature-measuring systems. Each shows how to solve a particular problem. 50 cents.

496—How to Specify Instrument Accuracy, 8 pp. This basic reprint is aimed at helping the user and maker to develop clear and mutual agreement on allowable instrument errors. Discussions of uncertainties of zero, scale factor, and instantaneous slope aid in the intelligent specification of allowable errors and preferred test procedures. 40 cents.

494—How to Use the Root Locus in Control System Design, 12 pp. Another reprint that translates theory into practice. Eight simple rules make locus construction easy, even including the effects of distance-velocity lags. Articles show how to interpret the locus diagram, determine transient response, and use locus techniques with multiloop systems. 45 cents.

489—Fundamentals of Multivibrators, 12 pp. Multivibrators are the electronic equivalent of the double-throw electromechanical relay and can perform substantially the same functions (memory, logic, gating, counting), but at enormously higher speeds. They can be built around vacuum tubes, transistors, square-loop magnetic materials, neon tubes, thyratrons, and cryotrons. This covers a broad selection of multivibrator circuits. 45 cents.

488—A Roundup of Control System Test Equipment, 24 pp. Specialized control system test equipment divides into three classes: 1) devices that only generate a test signal, 2) systems that both disturb the system and provide a means for evaluating response, and 3) devices that only evaluate control system response. 60 cents.

487—Survey of Ac Adjustable-Speed Drive Systems, June 1959, 16 pp. Regarded as constant speed devices, multispeed ac actuators actually take many efficient forms. The recent resurgence of interest in these ac adjustable-speed systems prompted this comprehensive coverage of pole-changing techniques, armature resistance control of wound-rotor motors, slip-frequency injection, use of eddy-current couplings, etc. 50 cents.

486—A New Way to Select the Best Control Valve, 16 pp. This three-article reprint gives rules for selecting the right valve characteristics based on static and dynamic considerations, takes into account the influence of piping on valve performance, and tackles the problem of sizing valves for maximum flow and for control rangeability. 50 cents.

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Ranges: 30,150,600 ma; 1.5, 6, and 15 A ac and dc; 30, 75, 150, 300 and 600 V ac and dc (33 ohms/v) 50 mv dc for use with separate shunts. Optional clamp-type current transformer increases the AC range to 600 A.

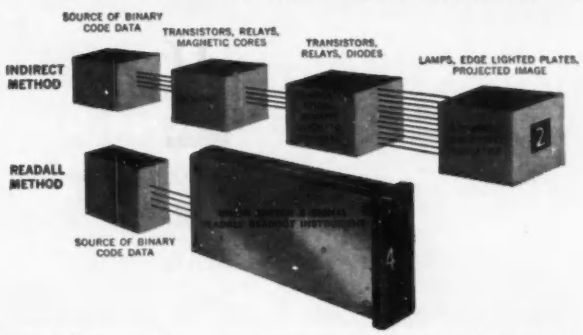
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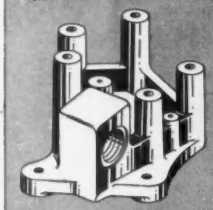
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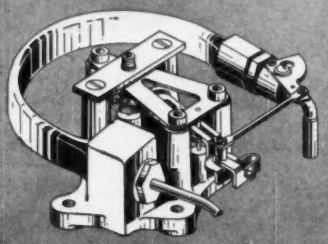
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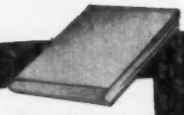
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* These advertisements appeared in the May issue.

(cut here) (cut here)

CONTROL ENGINEERING MONTHLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

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CITY..... ZONE..... STATE.....

HOME TELEPHONE.....

Education

PROFESSIONAL DEGREE(S) .....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

661

- ☐ Aerospace Control
- ☐ Components
- ☐ Computer Design
- ☐ Computer Application
- ☐ Computer Programming
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- ☐ Flight Instrumentation
- ☐ Guidance Systems
- ☐ Hydraulics
- ☐ Industrial Control
- ☐ Logic Design
- ☐ Machinery Control
- ☐ Man Machines
- ☐ Motor Control
- ☐ Nuclear
- ☐ Numerical Control
- ☐ Optics
- ☐ Pneumatics
- ☐ Process Control
- ☐ Process Instrumentation
- ☐ Servomechanisms
- ☐ Simulation
- ☐ Solid State Devices
- ☐ Switching
- ☐ Systems Analysis
- ☐ Other .....

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	Technical Experience (Months)	Supervisory Experience (Months)
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RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
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(CONTINUED FROM PAGES 202 & 203)

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1 each	16-31R Computer
Combination Amplifier	60
Summing Amplifier	56
Inverting Amplifier	24
Summing Amplifier, when not used in electronic multipliers	40
Total Amplifiers	200
Servo, Multipliers, includes 4 each 16-7N tapped cups	23
8B Resolver Multipliers	8
Potentiometer Padders	16
Digital Voltmeters	3
Danvo Diode Function Generators, 10 segment	6
Two Arm Plotting Board	1
Sanborn Records, total 20 channels	3

Geda Computing Equipment

2 each	L-3 Geda Computers
Operational Amplifiers	48
Coefficient Potentiometers	42
Servo, Multipliers	4
Sanborn Recorders	2

Digital Equipment

IBM 1620
Model 12 Otrac
(data reduction equipment)

For complete information about the availability of facilities, and how they can best serve you, contact **D. Voss, Radioplane, a division of Northrop Corporation, 8000 Woodley Ave., Van Nuys, California.**

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Searchlight Equipment Locating Service
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P. O. Box 12, N. Y. 36, N. Y.

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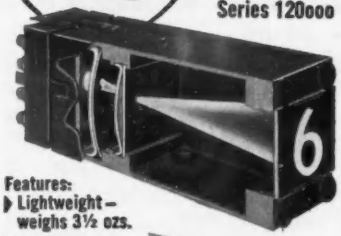
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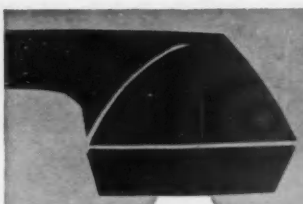
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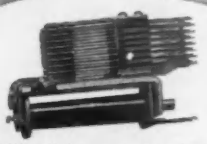
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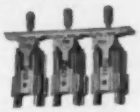
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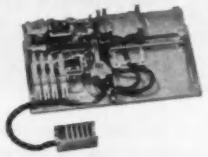
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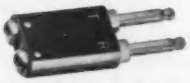
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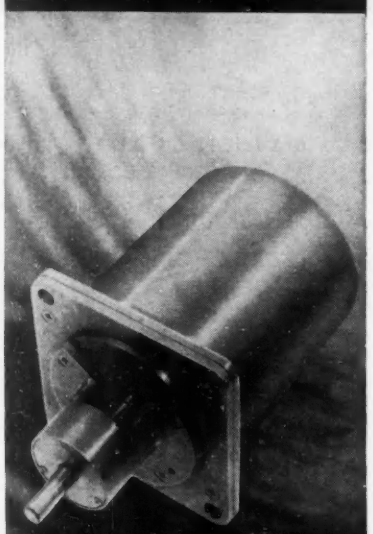
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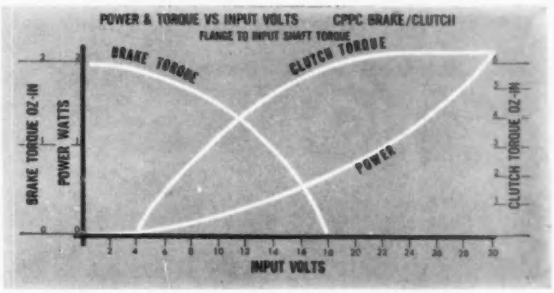
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Polar Moment of Inertia	
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